

©Copyright 2025
Gabrielle Benabdallah

Hermeneutic Engineering:
Material and Conceptual Tools for Open Systems

Gabrielle Benabdallah

A dissertation submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2025

Reading Committee:

Daniela K. Rosner, Chair

Nadya Peek, Chair

Audrey Desjardins

Afroditi Psarra

Program Authorized to Offer Degree:
Human Centered Design & Engineering

University of Washington

Abstract

Hermeneutic Engineering:
Material and Conceptual Tools for Open Systems

Gabrielle Benabdallah

Co-Chairs of the Supervisory Committee:

Daniela K. Rosner

Human Centered Design & Engineering

Nadya Peek

Human Centered Design & Engineering

In this dissertation, I argue that technological participation requires the parallel development of open technical systems and of interpretative practices that enable people to materially engage with, question, and reconfigure computational systems. Drawing from literary theory, textual studies, and the history of writing technologies, I present three case studies examining different modes of writing-with-machines. Imprimer, a computational notebook system for CNC milling, demonstrates how digital fabrication becomes interpretative when the system provides the space for engaging with complexity rather than abstracting it away. The Data Epics project transforms domestic IoT data into fiction, revealing how narrative modes of data representation made personal data simultaneously more and less legible. The Automated Writing Exercise inquires into text generation with large language models, exploring how automatic writing and algorithmic continuation create recursive spaces for material and interpretative engagement. Through an analysis and discussion of these three case studies, this dissertation suggests that participation in technical spaces does not come only from increased technical expertise but from interpretative openness, which can be enacted through 1) systems that scaffold complexity rather than hiding it, 2) modes of representation that materialize or visceralize computational artifacts, and 3) approaches that leverage the biases and glitches of systems as entry points into computational spaces.

By positioning interpretation as a material practice, and engineering as always containing latent spaces for interpretative work, I propose hermeneutic engineering as an orientation that questions the fixity and opaqueness of computational systems, accessible only to experts. Hermeneutic engineering thus encourages a change of attitude towards computational systems, from fixed and definite entities to sites of ongoing inquiry, reconfiguration, and material exploration.

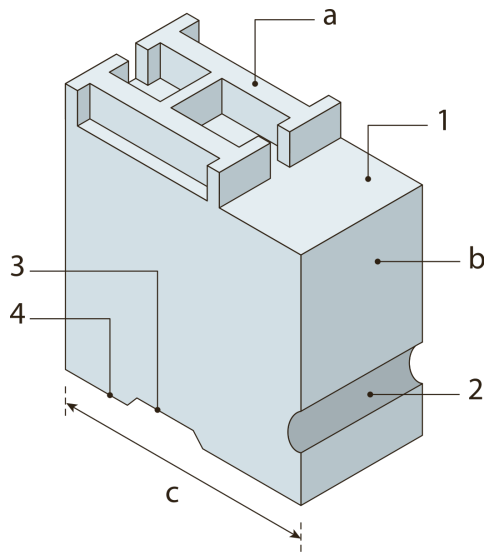
Hermeneutic Engineering

Material and Conceptual Tools for Open Systems

GABRIELLE BENABDALLAH

gabben@uw.edu

September 25, 2025



Hermeneutic Engineering

Material and Conceptual Tools for Open Systems

Advisors

DANIELA K. ROSNER

NADYA PEEK

Committee

AUDREY DESJARDINS

AFRODITI PSARRA

REGINA Y. LEE (GSR)

Candidate

GABRIELLE BENABDALLAH

GABBEN@UW.EDU

September 25, 2025

Table of Contents

Acknowledgments	III
1 Introduction	1
1.1 Tools for Thought	1
1.2 The Example of Writing as an Open System	2
1.3 Making Open Computational Systems	4
1.4 The Role of Interpretation	5
1.5 Cultural and Instrumental Approaches to Technology	7
2 Interpretation and Openness	11
2.1 Introduction	11
2.2 Literary Interpretation: A Model for Material Engagement?	14
2.3 Interpretation as Actualization	16
2.4 Conclusion	18
3 Writing with Machines	19
3.1 Introduction	19
3.2 The System of Imprimer	22
3.3 Notebooks as Interfaces	27
3.4 Notebooks as Sites of Exploratory Thinking	29
3.5 Notebooks as Sites of Material Engagement	32
3.6 Notebooks as Sites of Collaboration	35
3.7 Notebooks as Machines / Machines as Notebooks	36
3.8 Conclusion	37
4 Writing with Data	39
4.1 Introduction	39

4.2	Expanding Data Imaginaries	41
4.3	Making the Data Epics	43
4.4	The Data Epic <i>Hi! How Can I Help?</i>	45
4.5	The Process of Data Fictionalization	46
4.6	Close Reading of <i>Hi! How Can I Help?</i>	48
4.7	Data, Interpretation, and Open Systems	54
5	Writing with Transformers	59
5.1	Experiments in Algorithmic Writing	59
5.2	Glossolalia and Automated Writing	62
5.3	The Automated Writing Exercise	65
5.4	Iterations of the Automated Writing Exercise	70
5.5	Writing with Code(s)	75
5.6	<i>The Voyage In: Extending the Automated Writing Exercise</i>	78
6	Hermeneutic Engineering	83
6.1	Introduction	83
6.2	Participation through Interpretation	84
6.3	Interpretation as Material Practice	87
	Bibliography	105

Acknowledgments

This dissertation would not have been possible without the support and guidance of my mentors. The word “mentor” comes from the Greek mythological figure Mentor, who was a friend of Odysseus and became the advisor of his son, Telemachus, when Odysseus left for the Trojan war. Interestingly, Mentor is sometimes thought to have been Athena in disguise, who was really taking the place of Mentos, king of the Taphians. The details do not matter so much, but I do find it fitting that mentors are, etymologically, and through some historical misinterpretation of the texts, connected to the fierce Greek goddess of wisdom, war, and craft.

I say fitting because my mentors have been, in many ways, also goddesses in disguise, instructing me in all the skills and knowledge I needed in order to succeed in this great odyssey that is a PhD.

Afroditi Psarra showed me that the questions I wanted to ask could be asked not just with words but with materials, which set my life on a different course. She opened a new dimension.

Audrey Desjardins instructed me in how to design not just ambitious projects, but also joyous communities of research, and to move forward with equal measures of enthusiasm and rigor.

Nadya Peek taught me more things than can be listed, so I will only mention this one: that an unwavering demand for excellence, when coupled with solicitude, is one of the greatest forms of care.

Daniela Rosner revealed to me that it is possible to carve out spaces never seen before, in places where they need to be seen—and that to do so is necessary.

Thank you, all of you. I suspect I will keep unpacking everything you have given me for decades still. My gratitude for what I have learned and experienced thanks to you will never end.

CHAPTER 1

Introduction

1.1 Tools for Thought

Technological systems are never only technical. Technical objects and systems carry both the reification of processes (how they work) and the inspiration of possibilities (what they enable). To engage with technical artifacts and systems meaningfully therefore requires not only fluency in their operations but also attentiveness to the interpretive practices that make them legible and usable. In other words, it requires both attention to the “imaginaries and materialities” they join together [149]. This dissertation argues that in order to cultivate more convivial forms of computation, researchers and designers must attend to both the technical architectures of systems and the cultural practices that shape how they are used and extended. This requires open systems, i.e. systems that can be easily modified, repaired, and extended [13]. It also requires the development of a technical culture, i.e. a culture that pays attention to how materialities shape interpretative processes. Openness, as I define it in this dissertation, is therefore not so much a proprietary status (as in open software or hardware) but a mode of engagement; a condition for a sustainable, and sustaining, technical culture that supports interpretation and appropriation.

This argument is not new. Perhaps no fields have investigated the intersection of the material and the semiotic more thoroughly than media studies and textual studies. In *Programmed Visions*, Wendy Chun argues that software is both an operational substrate and a set of metaphors and habits; a medium that is simultaneously executable and ideologically encoded [25]. In *Mechanisms*, Matthew Kirschenbaum offers a forensic approach to digital materiality that shows how digital objects retain traces of their histories in their material substrate, and that a dual interpretative and technical form of inquiry is required to read them [78]. Johanna Drucker, in *Graphesis*, extends this argument by demonstrating how visual forms, such as diagrams, digital interfaces, layout, and typography, actively construct knowledge rather than only representing it [42]. Taking the text as a prime example of the role of materiality in the production of meaning, she writes that the text is “an event, rather than entity. The event is the entire system of reader, aesthetic object and interpretation A text is a highly complex system, containing a host of thermal sinks and basics of attraction” [41].

In this view, even the highly symbolic and conceptual technology of text is a system that depends on particular material arrangements to operate. In fact, if we dive into the history of textual technologies, we’ll find many useful models to think not just the interplay of meaning and materials, but also of how complex technical systems become progressively more accessible, open, and convivial.

1.2 The Example of Writing as an Open System

Let's take the example of writing in Europe in the Middle Ages. By that point, phonetic writing (writing the represented sound and not things and ideas, like pictograms) was a technology that had been around for about four millennia and that relied on the highly developed technologies of the codex (book in its bounded form) and paper [64]. Still, writing was painful, laborious, and exclusive. Books were heavy and chained to desks; script was dense and difficult to decipher; reading was slow, and writing slower still.

The very act of inscription left marks not only on parchment but also on the bodies of those who wrote: backs hunched, eyes strained, hands numbed, medieval scribes were acutely aware of the toll. They left marginal notes that resonate with traveled through the centuries to describe the agony of writing: “Thank God, it will soon be dark.” “I am very cold.” “Oh, my hand” [98].



Figure 1.1. 15th-century miniature of the priest and translator Jean Miélot. Public domain.

These laments reveal something about the early epistemic ecology of writing, namely that textual production was as much a physical ordeal as a cognitive one. Writing is far from being the smooth vector of thought it is often considered to be, but a laborious encounter between fallible bodies and highly produced surfaces, requiring expensive materials, training, and infrastructure. Writing was exclusive by design.

What changed? Not the technology itself but its material supports. A series of technical innovations, accumulated over centuries, transformed writing into a more convivial medium—one that could be appropriated by more people, in more contexts, for more purposes. The printing press, of course, figures prominently in this history. As Elizabeth Eisenstein argued, the advent of print in early modern Europe radically altered the conditions under which texts circulated, read, and endured [46]. But the press was only part of the story, and in fact, it built on several previous technical development: the normalization of the caroline minuscule, a script which developed as a calligraphic

standard in medieval Europe; the refinement of smooth paper; and binding techniques, among others [87]. Books became smaller, more portable, thanks to changes in folding: instead of folding the sheets in two (in folio), they were folded in eight (in octavo) in the 15th century. Literacy spread not only because more people were taught to read, but because more people were invited to through increasingly “friendlier” text interfaces and systems.

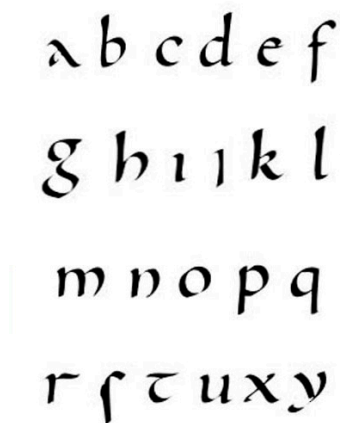


Figure 1.2. Many calligraphic and technical innovations preceded the invention of print. The caroline minuscule was a script developed in the 8th century and became a calligraphic standard in Europe. CC BY-SA 3.0

Writing gradually became integrated into daily practices, and that transformation was enabled through the design of new interfaces, which in turn fostered new conventions, and formats. Philosopher of technology Pierre Lévy reminds us that the words that make up the information and discourses of culture “are materialized, connected, presented, and highlighted for the reader by a network of interfaces accumulated and refined over centuries. Remove or add a single interface within the technical network of writing at any given moment, and the entire relationship to the text is transformed” [87].

When Ivan Illich cites the alphabet and the printing press as the epitomes convivial technologies [68], he overlooks the slow technical and cultural processes that *made* them so. Writing, like any technical system, became more accessible not through more abstraction and the hiding of complexity, but through the iterative development of practices and tools that allow that complexity to be navigated and reconfigured by others. In other words, writing became seamless not by hiding its seams, but through technical and cultural developments that made its seams interpretable. In this light, writing offers a powerful historical model of what I would call interpretive fabrication: the mutual calibration of conceptual and technical configurations such that meaning and materials can circulate without becoming fixed. The printed page, in all its apparent stability as an interface, was once a site of intense experimentation. Its legibility was hard-won [46, 73],

and its openness, far from being an intrinsic attribute, was a slow and gradual process of cultural and technical development. As I turn toward computational systems in this dissertation, the example of writing will be instructive to remember that the most enduring technologies of thought have always been those that welcomed interpretation.

1.3 Making Open Computational Systems

The aspiration for openness in computational systems has long animated the imagination of technologists, educators, and activists. From the ethos of open source hardware [oshwa] to the maker movement and the development of Fab Labs around the globe [47], openness has been presented as a technical principle: systems should be non-proprietary, designed to be extensible and shareable. Indeed, the open-source paradigm has radically reconfigured the production and circulation of software; and with initiatives like the Creative Commons and the open hardware movement, it has extended into material domains as well; “personal fabrication,” for instance, promised to democratize production in ways once unimaginable [53]. Yet this technical vision of openness often falls short of its emancipatory claims. Even when CAD files are freely available, the infrastructures required to use them, such as the equipment, as well as the training and the time to make things, are not equitably distributed. The material conditions of participation remain skewed. As scholars such as Daniel Cardoso Llach have shown, the cultural imaginaries embedded in systems of digital design still largely reflect the epistemologies of their originators: often white, Western, male, and technically elite [91]. Openness, in this context, is more a question of access and epistemic legitimacy, that is of who is imagined as a valid participant in the technological landscape.

I build on decades of rich scholarship and research that seeks to expand participation in and approaches to, computational making. The High-Low Tech group at MIT, for instance, directed by Leah Buechley between 2009 and 2014, sought to broaden participation in the development of “high tech” systems (computational) through “low tech” fabrication approaches (sewing, knitting, weaving, etc.) [151]. “Hybrid” approaches to computational fabrication were considered to bring expressivity and a more material-led relation to making than traditional approaches to CNC fabrication. In recent literature in design research, making has been articulated as a form of inquiry, in methods such as humanistic inquiry [128], design fiction [18, 18], or critical making [123].

Yet, even “print-based disciplines,” to use N. Katherine Hayles’s expression [63], are always *making*, even if only printed objects through writing. In *Making Things and Drawing Boundaries*, media scholar Jentery Sayers writes that technical making is often “conflated with (superheroic) command over people, situations, and things. In present-day “maker” cultures, consider the ubiquity of remarks such as “getting under the hood” or “knowing the nuts and bolts,” which tend to fuse logic with mastery, control with masculinity, engineering with rationality, and programming with revealing” [128]. Other approaches to participating in technical spaces are possible, often through the breakdowns and frictions, dislocations and discontinuations, the “hiccups and ambiguities” of computational and electronic systems, which Sayers call *conceptual matter*.

In this dissertation, I propose an additional perspective on making, one that treats it as both a technical and interpretive project. Through a series of case studies, I show how

practices of making can foreground openness not only as a technical agenda but also as a cultural and epistemic orientation. This approach is grounded in a close engagement with materials and an attention to their mediating role in meaning-making and appropriation.

1.4 The Role of Interpretation

What do I mean by interpreting? Chapter 2 of this dissertation more carefully discusses the traditions I draw from when articulating this concept, but I want to quickly introduce my own understanding of this key term in my dissertation. Interpretation is often associated with textual analysis and close reading; practices of careful attention and analysis of textual content. Indeed, interpretation historically emerged out of engagement with textual content, but developed in the 20th century into a broader philosophical project [59]. My own perspective on interpretation is heavily influenced by this literary and philosophical tradition, shaped by Wolfgang Iser [70] and Paul Ricoeur [125], among others, but also by a new generation of French literary theorists such as Yves Citton, Marielle Macé, and Thomas Vercruyse, who, while influenced by the philosophical hermeneutic tradition, developed an original approach to the work of interpretation and how it serves as a useful method for areas of inquiry such as politics [29], aesthetics [94], and epistemology [163].

I am particularly indebted to the work of literary historian and media theorist Yves Citton, who argues that interpretation is more than an analytical practice but a general condition of social and cognitive life [28, 30]. Citton claims that interpretation is the activity by which individuals and collectives reorganize existing elements (symbols and signs, but also gestures, or tools) into meaningful configurations. He writes:

“To interpret a text—according to the modalities at work in literary education or literary criticism—involves quite a different and more active attitude, insofar as it rests on questioning at least one of the three implicit assumptions that govern conventional reading. Either the interpreter is led to critically examine the code used, in order to clarify how it functions and what its possibilities are; or they come to perceive discrepancies between the way they decipher the text and the way they analyze the context of their reading; or they experience doubt, dissatisfaction, or frustration with what the text is presumed to offer as meaningful or relevant; or, finally, they find themselves facing a crisis on all three fronts at once (which is perhaps the most common case of interpretive activity).” [27]

While the literary mode of interpretation represents one extreme pole of interpretative work, this description by Citton is useful in identifying three modalities of interpretation, as well as its general movement with regards to an object of inquiry. In each of the cases described in the citation above, one enters interpretative work because one wants to understand *how things* (or the thing) *work*, whether on a semantic, aesthetic, technical, or other level (often times many levels are involved). And this mode of inquiry emerges when there is an opaqueness or strangeness (“in order to clarify”) or because the expectations of reality are not being met (“to perceive discrepancies”), or in the most extreme cases, because of frustration or doubt (“facing a crisis”). In all three cases, the proper movement of interpretation is one of *distance* rather than *adherence*, as one might experience when encountering a “fact.” Facts are indeed the modalities of knowledge that

invite no distance, because we have adhered to them: the sun is a star, water boils at 100 degrees Celsius, Ronald Reagan was the president of the United States of America in the 1980s. As soon as I enter the interpretative mode, I unstuck myself from the fact to figure out *how* this is accurate (water boils at 100 degrees celsius, but only at sea level atmospheric pressure—it might be different at higher altitudes).

In the context of encounters with computational artifacts, the interpretative mode is often active. At the most basic level, one might encounter a new piece of software and poke around to figure out how it works, making implicit decisions about which features to ignore and which to explore further based on one’s needs. At the most extreme level, one might experience dissatisfaction with a particular tool (say, a CNC machine) or digital phenomenon (say, data), and decide to modify said tool or to reconfigure modalities of encounter with said digital phenomenon. That too, I argue, is the proper work of interpretation.

To make, in the sense I propose, is also to interpret. Making is always a process of weaving together a variety of resources, whether technical, affective, historical, into forms that both function and signify. The kind of interpretative making I discuss in this dissertation is both technically specific and conceptually expansive. It is experimental and exploratory by nature, because it is more an activity of inquiry than it is of production. Interpretive practices enable appropriation without mastery. They allow for interaction with complex systems even in the absence of full control or complete understanding. It is a different orientation to fabrication that centers relation over execution, responsiveness over optimization. Not to say that one is better than the other, that execution and optimization are somehow ethically deficient whereas relation and responsiveness are more humane. All are required, always. Simply, participation in the technological landscape has inherited a history of technical performance that has prioritized narratives of production rather than process, of progress rather than remaking. Making should be more about re-making; about the reconfiguration of existing artifacts and systems, not for innovation’s sake, but for appropriation and participation.

Bringing this back to the question of openness: a technical system is not truly open if it can be modified only by those with formal engineering expertise, or only in the ways foreseen by its designers. Openness must be cultivated through usage practices that invite interpretation, that is practices that support (material, conceptual) experimentation and engagement with complexity. These practices often will scaffold entry, support partial understanding, and allow for repurposing in contexts the system was not originally built to accommodate, as I will describe in the following chapters. This requires rethinking not only technical architectures but also the cultures of making and use that grow around them. The projects explored in this dissertation are experiments in cultivating interpretive engagement with computational systems. They explore how openness is enabled through the development of more legible systems and more explicitly interpretative practices.

To insist on interpretive engagement in the context of technical participation is an invitation to reconsider how knowledge itself is produced and validated. There currently seems to be a split in how technical expertise is construed: one epistemic approach is grounded in partial understanding and situated experience [60]; the other in technical precision and validation [134]. The section that follow take up this simplistic split and troubles it as an epistemic *seam* that in fact joins together a common objective of tech-

nological participation, but from different sensibilities.

1.5 Cultural and Instrumental Approaches to Technology

The contrast between interpretative and technical epistemologies—to go fast, between the humanities and engineering—is often imagined as a disciplinary or cultural divide: the former oriented toward meaning, and the latter toward making. This dichotomy has been reinforced historically by institutional boundaries and epistemic conventions, as well as by the media ecology that scaffold each domain: books, essays, and marginalia on the one hand, schematics, blueprints, and more recently code, on the other. Consequently, the humanistic and engineering traditions have also been connected with different attitudes towards technology, which historian of technology Eric Schatzberg describes as the cultural approach” and instrumental approach” approach to technology [129, p. 12]. The first is “human centered” and views technology as a “creative, value-laden human practice. In this view, all humans are the rightful heirs to technology, not just technical elites.” The instrumental approach, by contrast, views technology as a mean to an end, and therefore devoid of values and sitting “outside of culture,” to paraphrase French philosopher Gilbert Simondon [135].

Yet, it is important to note that these distinctions, as Schatzberg points out, are specific to *scholars* of technology—not makers. Engineers themselves would most likely agree that there is a cultural dimension to the systems they build, and several view their work as the expression of ideological, political, and social projects [129]. The instrumental view, however, is not without sway in how it shapes culture, effectively effacing the role of human agency and promoting a technodeterminist view which has very real consequences in how computational systems serve to accumulate and retain power [110, 111, 146].

My own interest in these questions is in how these traditions shape possibilities of participation in making and remaking technology. Currently, the options seem to be to either develop critical and historically informed perspectives on technology through a humanistic curriculum that is woefully disconnected from the reality of technical practices, or to train as an engineer and forego the kind of training that is perhaps the most important one can receive in a formal context in the age of AI: the training that teaches one how to think, and to be aware of its own metacognitive propensities.

The binary between interpretative and technical epistemology also obscures a more generative insight: that interpretative and technical epistemologies are not so much different in kind as they are in material substrate. Both are modes of inquiry (ways of knowing the world) grounded in the selective reconfiguration of existing forms. Both are engaged in processes of analysis, synthesis, and transformation. What differentiates them, crucially, is not their aims, but how they evaluate their aims: one through the realization of thought processes in the form of writing (most generally), and one through the realization of thought processes through materials, which we call things (artifacts, tools, systems).

The gap between writing and things—between *les mots et les choses*, as Foucault might have said [48]—is really where the rubber hits the road when it comes to epistemic categories (and ontological ones as well, but that is another dissertation). Interpretative epistemologies have long privileged the symbolic and the conceptual: they work through

language, metaphor, narrative, critique. Their materials are soft, malleable, and open-ended; words are polysemic, always, which encourages reconfiguration. As Simondon wrote, “there is no difference between discovering a meaning and existing collectively” because meaning is a property of relation; words facilitate relations [136]. By contrast, technical epistemologies often operate through systems that seem more definitive: circuits, enclosures, even algorithms. But this perceived rigidity is an illusion; computational systems are no less malleable than words, than only require different tools and literacies. They, too, are open to transformation and they, too, facilitate relations.

Additionally, the very process of making tools and systems is itself an interpretative process. American philosopher Donald Schön has shown in *The Reflective Practitioner* that design and technical work involves ongoing processes of reflection-in-action, in which the designer or engineer engages in a kind of conversation with their materials [130]. Schön’s emphasis on the iterative nature of expertise challenges the binary distinction between conceptual and procedural knowledge. Engineering too is interpretative.

This insight has become increasingly urgent in the context of computational technologies, which often demand both interpretative and technical fluency. Matthew Kirschenbaum demonstrates how digital systems and standards, such as file formats and disk images, require interpretative reading [78]. His forensic approach proposes tools to read how digital objects retain traces and inscriptions. Engineering practices are of course shaped by cultural values, histories, and social imaginaries, as shown by Daniela Rosner [126]. Rosner offers a vision of technical work as a form of storytelling, in which materials participate in the ongoing negotiation of meaning. Even when oriented toward functionality, engineering and computing involve the continual reinterpretation of constraints and affordances. Seen from this vantage point, the interpretative and the technical are not separate cultures, as argued C.P. Snow in the 1960s [139], but different inflections of a shared pursuit: making sense of the world through engagement with its forms. The key difference lies in the resistance of the *medium*. Media ecologies profoundly shape the possibilities of knowledge, as several scholars across disciplines have shown [48, 46, 45, 64, 34, 115, 61]. The physicality of the medium matters: concepts and symbols afford a kind of plasticity that materials like silicon or aluminum do not. But this does not mean one is expressive and the other merely “instrumental”. Rather, the expressive possibilities of each emerge through their specific material constraints, whether the material is language, code, data, wood, or clay. Technical epistemologies, like interpretative ones, are grounded in this expressivity.

Engineering, in fact, has deep roots in craft traditions, as Eric Schatzberg notes. The disciplinary distinctions that later emerged between “technical” and “cultural” work were the result of complex institutional and industrial dynamics [129]. Today, there is a need to recognize that technology is a human reality, to paraphrase Simondon [137] and therefore the purview of humanistic and social science inquiry, that is of interpretative epistemologies.

This dissertation discusses three case studies in which technical systems are treated as interpretative media, and interpretative practices are extended into technical domains. Rather than holding these epistemologies apart, I propose that their overlap offers a more useful foundation for building open, legible, and convivial technologies. The goal is not to dissolve all difference between technical and interpretative ways of knowing, but to attend to how they might inform and enrich one another through their distinct orientations. To

engage with technology meaningfully, we must think both with our tools and about them. We must interpret not only texts, but systems. This dissertation is an invitation to see technical systems not as finished artifacts, but as events, to use Drucker's term—moments in an continuous technological and cultural unfolding. Hermeneutic engineering is an invitation to imagine what technological participation can look like across a wide spectrum of technical fluency.

CHAPTER 2

Interpretation and Openness

“Hermeneutics of difficulty consider that the [idea] of literal meaning [in texts] is problematic It will be interpretation which supplies the meaning. Meaning is not inherent to the text but to the interpreter, who takes responsibility for its risk. Interpretation is therefore understood ... as a “school of responsibility.” ”

—Thomas Vercruyse, *Kairologie: Pour une poétique de la circonstance*, 2021 (my translation) [163, p. 43].

2.1 Introduction

What is interpretation? In this chapter, I argue that the process of interpreting something is always process of appropriation and adaptation. Through the example of literary and media interpretation, I show that there is always a form of reconfiguration or transformation at play in interpretation, making the activity a creative and hands-on modality of engagement.

American artist and theorist Victor Grauer has developed, since the 1970s, among other philosophical and artistic projects, a very ambitious theorization of artistic practices according to modernist theory. In some ways, his theorization was developed in parallel and in echo of what French philosophers Jean-François Lyotard or even Gilles Deleuze were developing on the other side of the Atlantic. His unified theory of the arts was based on the notion of field, which he defines as “a kind of invisible controlling space-like region or extent within which certain types of activity have the potential to take place” [56]. Having absorbed much of post-structuralist theory, Grauer was interested in *semantic* fields in particular, to which he drew parallel with field in the domain of physics: “For Faraday, followed by Maxwell and Einstein, what is fundamental are the fields—electromagnetic, gravitational—through which forces and matter can be understood to operate. Similarly, we can consider a syntactic field as a controlling, determining, fundamental entity of function by means of which syntax and signs can be understood to operate.” The notion of syntax is crucial here, and signals, in accord with its Greek etymology, that syntax is about placing (*-taxis*) together (*-syn*) various elements within a structured space that allows to identify said elements by seizing the different relation-

ships that constitute them. Without a clearly defined syntactic field, no figure can ever be identified in a satisfying way. They are only apparent as undifferentiated, ambiguous marks (in the visual domain) or noises (in the aural domain), marked by indecipherability. But what Victor Graeur is interested in is less the absence of a syntactic field than the eruption or the manifestation within an existing syntactic field of phenomena which he calls “ungrammatical.” In the realm of music, an ungrammatical occurrence would be perceived as a jarring note within a certain melody. In the visual realm, Graeur gives the example in Figure 2.1.

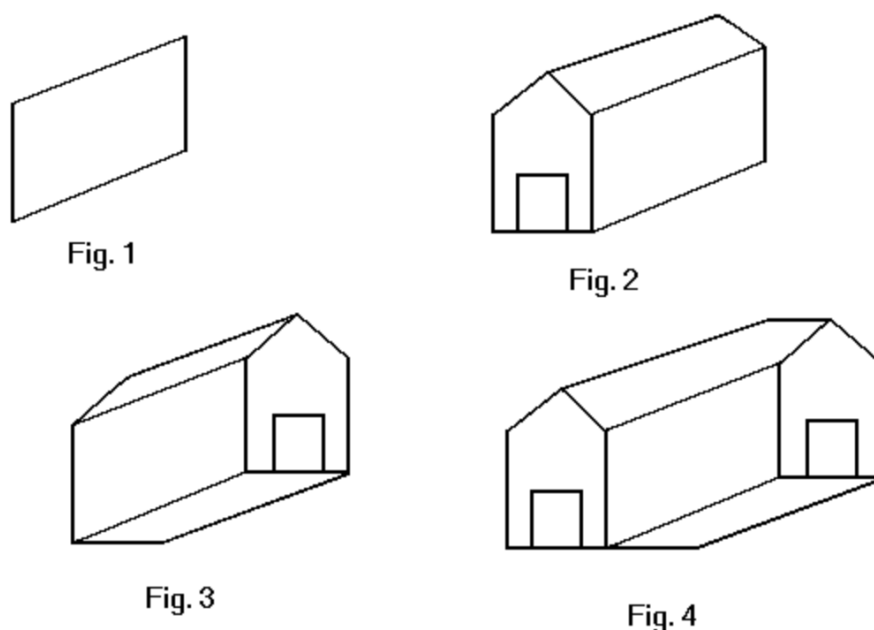


Figure 2.1. How “ungrammatical” moments can happen in the visual domain, according to Victor Graeur [56].

Figure 1 shows a parallelogram which is inscribed within a two-dimensional field without necessarily evoking anything else but itself. If we add a few marks, the second figure suddenly indicates a three-dimensional space and also evokes a house with a door. It also creates a polarized orientation within the perceptual field. If we add more marks to the original parallelogram, we get figure 3 which keeps the three-dimensional space and the evocation of a house but articulates a different polarization of the perceptual field. Something “ungrammatical” happens with figure 4 which, by compiling figures 2 and 3, suddenly makes it impossible to perceive the original parallelogram according to a stable and non-ambiguous orientation.

This principle of the “ungrammatical” is tied to the modernist evolution of painting towards abstraction, which by definition is self-referential art, drawing the viewer’s attention to the phenomenality of painting itself, rather than a subject matter *per se*. This is because the experience of the ungrammatical cannot be reduced to the categories of perception within which we try to make sense of “syntactically correct” figures and elements. Instead, the ungrammatical invites the viewer/listener/user to perceive the very

materiality of the object that presents itself to their attention. It disrupts meaning to the extent that it momentarily dislocates the expected configurations of the perceptual field, and by extension, of the semantic field. It produces a certain *undecidedness* that allows for multiple interpretations and meanings to emerge.

Graeur’s ideas about the syntactic field and the ungrammatical are relevant not just to the arts but to technical systems as well (after all, the Greek *tekhnē* does mean “art” or “system of making or doing”). What is “ungrammatical” in the objects of culture is what Jentery Sayers calls the “discontinuities and ambiguities” in computational systems, and always opportunities to realize “the inability to unmoor materials from how we interpret materials” [128, p. 17].

To identify and grapple with what is ungrammatical, complex, ambiguous, discontinued, opaque, “black-boxed,” is the proper work of interpretation.

The interpretative approach cultivates a way of engaging with the world that extends to all forms of human productions. It trains the mind to see how meaning is constructed, both materially and conceptually; how the specificity of media informs content: how news articles rely on metaphor and rhetorical framing to shape political narratives; how a documentary’s authority rests on techniques of lighting, editing, and sonic affect; how even photographers who seek to merely “show reality” are always “haunted by tacit imperatives of taste and conscience” [140, p.4]. To interpret is to unearth these mechanisms, to see more clearly the aesthetic, rhetorical, and material conditions under which knowledge, perception, and reality itself are produced. This is the beginning of an interpretive sensibility: a way of reading the world, less as a fixed collection of facts or things, but as an ongoing production—a world continually made, and remade through attention.

Machines and systems are always already embedded in social imaginaries and shaped by human choices [149, 157, 110]. Yet, for most people without technical training, computational systems remain largely illegible. A smart camera or a chatbot is rarely approached as the product of a particular series of formal, technical, and aesthetic choices. Instead, they present themselves as fixed, closed, and “given.” Even when their mechanics are transparent, like the graspable form factor of a mug, they often seem to resist intervention, as though their existence had been decided elsewhere, in distant and inaccessible domains of technical authority. They appear not as arguments, or invitations, but as facts.

Philosopher Gilbert Simondon wrote that “Culture has constituted itself as a defense system against technics; yet this defense presents itself as a defense of man, and presumes that technical objects do not contain a human reality within them” [135, p. 9]. Technical objects and systems, which include computational ones, are overly determined by the fact that they are functional, means to an end, according to Simondon. But what would it look like to consider tools as human productions that express just as much about human artistry and experience than films or texts do? To let tools express their “inner lives” or manifest “inventive spontaneity” [137, p. 251]? What if technical systems were approached less as finished products and more as materials—malleable, and open to interpretation? What if, instead of seeing them as opaque and finished, people encountered them as grounds for intervention and reconfiguration? To think of technical systems as materials is a reminder that these systems are made—and can therefore be remade.

Interpreting and remaking the technical world is essential if we are to live meaningfully within it. Simondon’s argument on the alienation caused by the misunderstanding of

technical objects is grounded in the observation that as long as any aspect of human reality is not integrated into culture, culture remains unbalanced. Interpretation is the necessary precursor to participation—only when we begin to understand how things are made can we begin to imagine how they might be otherwise. Moreover, interpretation, as opposed to reading, enlarges life, because it demands active participation in the possibilities of creating new meanings, new configurations, and new value for the collective. The goal of interpreting texts, films, plays, or paintings is not to add to the growing mass of human knowledge. The goal of interpretation has indeed never been knowledge, but transformation. To understand and appreciate human productions means to engage with the myriad expressions of human experience, which in turn shape the possibilities of what they can be. The fact that technical systems have been excluded from this inquiry has been only one of the many exclusions the humanities were founded on [24].

In this chapter, I lay the groundwork for this view by showing how interpretation works—what I mean by it, and what kind of “work” it can do. I present interpretation as both a conceptual and material form of engagement, capable of transforming not just how we understand the world, but how we act within it. I focus specifically on literary interpretation, which in the West has a long tradition going back to the earliest texts of the canon, and is a quite mature, and quite technical, field. I begin by drawing on literary theorist Yves Citton’s notion of interpretation as actualization—a process through which readers generate new realities by attending to and amplifying potentialities in texts. For Citton, this is not only an aesthetic practice, but a civic one: interpretation is vital to the functioning of democracy. I then turn to a more historical and material example: the commonplace book. A humble but powerful media form, the commonplace book demonstrates how earlier media were used to engage with and make sense of complex informational environments. These notebooks, which were collections of quotes, excerpts, songs, recipes, thoughts, and other fragments of post-print early modern European culture, were idiosyncratic and unpolished; they were not about expertise, but about participation. They represent a kind of interpretive authorship, grounded in everyday acts of selection, annotation, recombination, and reflection.

Through these two examples—one theoretical, one historical—I propose that interpretation can serve as a mode of material intervention, and as a methodology for engaging technical systems.

2.2 Literary Interpretation: A Model for Material Engagement?

If technical systems are to be approached as malleable and meaningful human productions, we need interpretative tools robust enough to engage with complexity, ambiguity, and opacity. Interpretation, which the Western literary tradition has formalized and refined over centuries, offers one such tool. While rarely mobilized in the analysis of technical artifacts, literary interpretation cultivates precisely the kind of perceptual and conceptual flexibility needed to navigate complex and layered systems. One particular tradition of literary interpretation I draw from is textual studies. Textual studies are historically grounded in the study of manuscripts and printed texts, and has long been aligned with hermeneutics—the art and theory of interpretation. With roots in classical

philology, textual scholarship developed methods to address the “instability” of text—the fact that texts, even printed ones, are not fixed entities but often go through several transformations, whether in the forms of revisions, new versions and editions, adaptations, etc. The discipline initially involved tracing their transmission and editorial shaping, focusing on the patient (and hopefully comprehensive) work of recording, documenting, and archiving texts and their versions [57]. But these early practices, as David Greetham writes, were “not merely a dry, mechanical, tedious investigation of physical fact but, like all other intellectual activities, operate[d] under various theoretical persuasions” [57, p. 342]. That is, textual studies has always been looking for clues as to the significance of textual works in their material history; it has always been interpretive, concerned with recovering the past in service of better understanding how texts are read and valued.

The deep entanglement between textual studies and hermeneutics was made explicit in the shift away from authorial intent as the sole anchor of meaning. The “New Bibliography” [58] and its emphasis on establishing definitive texts through mechanical collation were critiqued by theorists like Jerome McGann, as well as Roger Chartier, who re-centered the role of readers, editors, and socio-material contexts [101, 22]. Later, the field’s engagement with post-structuralism further emphasized that texts are never fixed: they are always already plural, contested, and situated. This openness to theory, and perhaps more importantly, to the shift of textual instability from material to semantic concerns, set the stage for a reinvention of the field in response to the rise of digital and computational media.

New media—the term used by media theorists to talk about computers—might at first appear foreign to a tradition so deeply invested in the printed word. Yet textual studies offers precisely the tools needed to grapple with their complexity. In *Mechanisms*, Matthew Kirschenbaum argues that textual studies should be seen as “among the most sophisticated branches of media studies we have evolved” [78, p. 16]. Building on D. F. McKenzie’s definition of text—“I define ‘texts’ to include verbal, visual, oral, and numeric data, in the form of maps, prints, and music, of archives of recorded sound, of films, videos, and any computer-stored information, everything in fact from epigraphy to the latest forms of discography” [103]—Kirschenbaum positions textual criticism as a critical lens for digital media. He notes that while electronic editing projects have proliferated—such as *The Electronic Beowulf* and *The William Blake Archive* there has been “very little consideration of digital media themselves from the specific vantage points of bibliography and textual criticism” [78, p. 27]

This space is where this dissertation intervenes. By treating digital systems not as fixed artifacts but as ongoing processes, I reframe these systems as materials for interpretative engagement. The legacy of textual studies is not confined to books—in fact, I argue that because of its consideration of specific media, it has developed capacious approaches to consider and form meaningful analyses for all media, including computer systems. The legacy of textual studies is a legacy of attention: to the layers of materials and techniques that shape expression, to the histories embedded in form, and to the ways these material histories shape interpretive practices. Greetham writes that textual criticism is “the exemplary discipline for these days of a ‘hermeneutics of suspicion’ that motivates its editorial and interpretive labor [57, p.296]. I see this suspicion as an ontological stance that questions the seeming stability of artifacts, from texts to machines. By drawing from textual studies as a mode of interpretive and material inquiry, I leverage its

attentional and hermeneutic practices for the study of digital systems. In what follows, I turn to another register of interpretative work. Drawing from literary theory, I discuss the notion of actualization, the process of leveraging the complexity or opacity of texts (and of all artifacts) to shift existing configurations of perception and value.

2.3 Interpretation as Actualization

The literary tradition is rarely cited in the context of understanding technical systems. Yet, literary interpretation offers rich insights into how meaning arises not despite ambiguity, but through it. These insights are essential when dealing with digital systems that are often opaque, resist easy explanation, and yet are saturated with social and cultural charges. By turning to literary interpretation, I aim to reframe our encounter with digital technologies not as stable systems but as expressive and reconfigurable artifacts.

This view somewhat diverges with the definitions of interpretation given by Jeffrey and Shaowen Bardzell in *Humanistic HCI* [11]. The authors argue that interpretation in HCI transcends functional utility (as in interpretation deals only with how users might understand the function of a system) and instead embeds systems within broader socio-cultural and ethical frameworks. The authors share two “major formulations” of interpretation to shed light on what interpretation is and how it works. The first is from the Canadian philosopher Charles Taylor:

“Interpretation... is an attempt to make clear, to make sense of an object of study. This object must, therefore, be... in some sense confused, incomplete, cloudy, contradictory—in other way or another unclear. The interpretation attempts to bring to light an underlying coherence or sense. This means that any science that can be called [interpretative]... must be dealing with one or another of the confusingly interrelated forms of meaning.” [150]

The second definition the Bardzells share is from aesthetic philosopher Noël Carroll:

“Interpretation ... goes beyond the given in order to establish the significance of what has been given. Interpretation is concerned with significance—for instance the thematic significance or the narrative significance of an artwork or the significance of the behavior of a character in a fiction or the interrogation of the import of a metaphor [...] Typically, interpretation involves the process of abduction—hypothesizing from the various parts of an artwork to the theme or message or idea or concept that best explains why the assemblage of parts before us coheres together as a whole [...] Interpretation aims at excavating the sense of the work.” [20]

These definitions adhere to a view of interpretation as an exhuming process rather than a fabrication one, and imply that meaning is tied to intent alone and must be carefully “excavated” from the murkiness of form by the delicate tools of hermeneutics. In Taylor’s quote, interpretation is mainly understood as a practice of clarification and revelation. The objects of interpretation are “unclear” or “incomplete,” their signification muddled, and interpretation can restore the objects to the full brilliance of their meaning. The

focus on clarification misses the heuristic potential of interpretation however, not only as a way to shed light on obscure phenomena but also to create new perspectives on familiar and seemingly well-known things. In this sense, Carroll’s quote, while also using the excavation metaphor, points at the role of interpretation as a mechanism of value production—what he calls significance. Things are not inherently valuable—their value is determined in the interaction with an audience or a user. Interpretation is the name given to the work that gives form to value.

Value can be hard to establish sometimes because the artifact or phenomena is not immediately understood—as might be the case in the context of a complex or novel system. This is great news, as things not immediately understood can signal an opportunity for fresh perspectives. Interpretation, in fact, actively seeks out such moments of opacity or ambiguity, and treats them “as privileged sites for interpretive work” [28, p. 137]. Yves Citton writes that:

“[a] century of interpretive practice has taught us to turn sites of resistance to meaning into strategic points for the emergence of “truth.” Nothing is more tedious than a textual analysis that merely confirms how clear and well-ordered the narrative is (“well-written,” “rhetorically mastered”). Interpretation truly begins with the grain of sand that jams the machine that produces obviousness, ... with the detection of an incoherence, an unexpected detail, a “deviation” ” [28, p. 128] (my translation).

The moment of misunderstanding, or confusion, is actually an opportunity, says Citton. He highlights the transformative potential of interpretation by emphasizing the value of disruptions, inconsistencies, and ambiguities in a text. Interpretation is not just a clarifying act, but a reconfiguration of the categories of perception, made possible by an opening of both the objects of inquiry (text, systems) and of the mind that apprehends them. Rather than seeking smoothness or coherence, a literary reading thrives on moments where the text resists easy comprehension, which we might call “ungrammatical” moments, after Graeur. Literary interpretation matters here because it cultivates the perceptual and symbolic flexibility needed to engage meaningfully with a world shaped by complex and layered systems. Citton suggests that literature operates not only through aesthetic immersion but through reconfiguration—of perceptions, of “categories of the sensible,” of the very structures by which meaning is assigned. Interpretation, in this view, activates new arrangements.

The lesson here, particularly for interpretation of technical systems, is that complexity should be embraced. Interpretation, as a method, becomes a kind of sensing, attuned to resonance, rhythm, slippage, and potential rather than certainty or consensus. It is much more an embodied process than a purely theoretical one. This mode of attention is precisely what is needed when approaching technical systems not just as artifacts, but as ongoing processes of socio-technical negotiations [136]. By engaging with objects and systems in this way, we learn how to work with mechanisms that are hidden. Interpretation provides a method for inhabiting complexity. And crucially, it teaches that this complexity is not an obstacle to be tamed, but a condition for invention.

In the context of material engagement with digital systems, this means that the material “resistance” of machines, algorithms and data can be leveraged as sites of interpretation and inquiry, and lead to more substantive relationship with digital objects.

Through the opportunities of reconfiguration it presents, interpretation transforms not only the object of inquiry but also the interpreter, broadening their capacity to perceive and contend with complexity, ambiguity, and multiplicity in systems.

2.4 Conclusion

So far, I have outlined two key traditions that inform my approach to interpreting technical systems: textual studies and interpretation as actualization. Textual studies offers a methodological and historical grounding, showing how attention to materials, and material history in particular (which Simondon might have called *mecanology* [137]) reveal the constructedness of artifacts. From there, I turned to the idea of interpretation as actualization, drawing on Yves Citton's work to suggest that complexity and opacity are not barriers to understanding but invitations to reconfigure perception and value. Interpretation, in this sense, is a creative act that remakes both object and observer.

In summary, I have argued that interpretation is not so much a method for clarifying meaning, but a mode of creative, material engagement with the world. Drawing from textual studies, I highlighted how media artifacts—from manuscripts to digital systems—are shaped by layers of technical and historical processes, and that attending to these layers is already a form of interpretive labor. Building on this, I explored literary interpretation as a method of actualization, where ambiguity becomes a resource for generating new meanings and shifting perceptual frameworks. Together, these traditions offer a foundation for rethinking how we approach technical systems: not as fixed and opaque objects, but as expressive, reconfigurable artifacts *open* to intervention. This interpretive lens sets the stage for the case studies that follow, which explore how digital tools and systems might be re-encountered as sites for situated, material participation ¹.

¹Here, I distinguish from Marres' notion of material participation, which she describes as a "distinctive mode of engagement" which foregrounds material actions, "like washing or foresting," as having political significance or value [99]. By contrast, I define material participation as a mode of engagement with computational systems that involves some form of material intervention: making, remaking, extension, customization, repair, maintenance, and/or reconfiguration.

CHAPTER 3

Writing with Machines

“ A metaphor of weightlessness and immateriality dominates computational discourses about design. ... Despite recent appeals to materiality, particularly in discourses about “digital fabrication” in architecture, material formations are generally considered an effect of these ethereal transactions. Thus, the materiality of digital information, its (often messy) substrates—such as wires, voltages, disks, and drives, as well as the socio-technical processes involved in its definition and production—is black-boxed: hidden from view.”

—Daniel Cardoso Llach, *Builders of the Vision: Software and the Imagination of Design*, 2015 [91, p. 32].

3.1 Introduction

This chapter builds on the broader argument of this dissertation: that computational systems never only pertains to what I call a technical epistemology, but that they are always building on the legacy of interpretative traditions—often ones inherited from or entangled with the legacy of print. Each chapter in this dissertation examines how specific computational practices—designing with CNC machines, interpreting data, writing with AI—extend or reinterpret models of inscription developed in print cultures. At stake is the possibility of cultivating a computational humanism, one that makes space for interpretative practices with and through technical systems, and that cultivates technical knowledge as an intrinsic dimension of interpretative practices. To frame this inquiry, I return to a historical divide that continues to shape contemporary relationships with computational systems: the split between interpretative and technical epistemologies. On one side lies an interpretative tradition, associated with print culture, where meaning emerges through selection, framing, annotation, and symbolic reasoning. On the other side lies a more technical tradition, associated with computation and engineering, often oriented around implementation, efficiency, and proof-of-function. While these are not inherent to media themselves, the social and historical development of print and digital

technologies has fostered these respective orientations.

This epistemic split has shaped disciplinary divides between the humanities and the sciences, and, more relevant to this chapter, shaped the design of software and hardware systems. It has also contributed to a broader cultural context in which the interpretative possibilities of computation are often underdeveloped. Despite the emergence of interdisciplinary fields like digital humanities, design research, and the development of approaches that seek to bridge material and interpretative epistemologies like critical making, the dominant computational culture still tends to prioritize solutionism and instrumental rationality over ambiguity, reflection, or critique. This is particularly true in domains like digital fabrication, where the user is often positioned as an executor of commands, not a participant in an open-ended inquiry. This observation is in fact the starting point of the system discussed in this chapter, *Imprimer*, a system for interactive CNC milling. The design of *Imprimer* as a system that relies on computational notebooks for tool paths design and machine control shows that digital fabrication is an epistemic practice that generates knowledge on materials, machines, code, community, human and physical resources, and the workflows that weave all these elements together. Daniel Cardoso Llach, who researches computational design and fabrication media, calls these elements the “social, technical, and material substrates” of inscriptions, that is the technologies of representation that enable computational fabrication [91]. These technologies of inscription are precisely the ones that this chapter focus on, specifically computational notebooks, and their analog counterparts, developed through manuscript and print culture, notebooks. According to Cardoso Llach software embodies theories of design, and structure the very possibilities of interaction between human and machine. Representation, in this context, is a site where thought is first externalized, and later formalized to produce various effects—in the case of CNC, to automate fabrication processes and operations.

Cardoso Llach shows, like David Noble [110], that the genealogy of digital design tools is rooted in the Cold War ambitions of simulation, control, and prediction. The drawing tools of CAD systems are descendants of inscription devices that were designed to regulate and control as much as to visualize—or perhaps that is always the goal of visualization. As such, Cardoso Llach’s historical analysis is useful to the argument of this chapter in that it shows how fabrication became a domain where the epistemologies of notation and of interpretation—how we write, represent, and externalize ideas—are intimately linked with the realities of physical manifestation and material life. To draw a line in CAD is to make a claim about how form should behave under computational and physical transformation. It is not incidental that *Imprimer* uses a computational notebook as the site where fabrication becomes interpretative. The notebook is a format with a long history that connects it to practices of material and conceptual exploration and experimentation. From the commonplace books of the Renaissance to the lab journals of experimental science, analog notebooks have long served as capacious inscription devices that accommodate a wide variety of content and formats. Even in their constrained physical form, they have displayed a kind of epistemic capaciousness: a tendency to accommodate heterogeneous media, provisional ideas, annotations, sketches, and extensions across domains. This inherent extensibility finds its full expression in computational contexts. As Fernando Pérez, co-founder of Project Jupyter, writes: “Even today’s ‘Jupyter Notebook’ is a bit of a misnomer. . . [it includes] a file manager, a text editor, a terminal

emulator, a monitor for running Jupyter processes... and that is just what ships ‘out of the box,’ without counting the many third-party extensions.” [75] The name “notebook” persists, and I argue that it is the perfect name for this project, because of the affordances of notebooks to accommodate a wide range of media, contexts, and contents. Imprimer builds on this legacy of extension. Its Observable-based notebooks both visualize toolpaths and directly dispatch instructions to a CNC milling machine, effectively transforming the notebook from a representational interface into a machinic one. In this configuration, the notebook is both an inscription devices (in which programs and documentation can be written, tool paths visualized and represented) and and fabrication device. It becomes, in a very real sense, a machinic notebook—a site where inscription meets material intervention, where writing becomes cutting, and where the legacy of the manuscript and analog notebook is extended into the realm of computational making.

Imprimer emerges out of the same genealogy that Cardoso Llach traces to the development of the Automated Programming Tool (ATP) at MIT in the 1950s, a project led by Douglas T.s Ross, then a young mathematician who had worked in the Servo Lab. “Ross’s fundamental concern was representation” writes Cardoso Llach, “[He] pondered how to represent points, lines, problems, and even complex artifacts such as houses and circuits, or even language itself... .” [91, p. 43]. Similarly, a key interaction problem with Imprimer was how to represent tool paths so that the maker could have a sense of what would happen once the commands were sent to the machine. The solution of Imprimer to use computational notebooks expanded this initial goal not only by providing graphics capabilities to the flexible interface—especially powerful with Observable notebooks [113], built on Java script, and which use D3.js visualizations. D3.js is a powerful visualization library developed by Mike Bostock, Vadim Ogievetsky, and Jeffrey Heer, that is used for creating interactive and dynamics visualizations [33]. But the use of Observable notebooks to generate, visualize, and dispatch tool paths is also an opportunity for the maker to engage with the underlying programs that control the machine, which are otherwise hidden in abstractions or hard to edit through straight g-code, which has limited programming capabilities. This feature of Imprimer foregrounds the representational and notational nature of fabrication. Rather than hiding toolpaths within proprietary software, Imprimer exposes them in a modular, editable, and annotated form. In doing so, it invites users to engage in fabrication not as execution, but as interpretation: to read, modify, and experiment with code, material constraints, and visual feedback in an open-ended loop of reflection and iteration. This shift has important implications for how we understand the relationship between code and matter, and for how code comes to matter. Imprimer is an illustrative example of how fabrication is a space of epistemic negotiation that sits at the intersection of interpretative and technical cultures. Imprimer makes this explicit by aligning itself with traditions of literate programming [80] and interactive fabrication [166], traditions which resonate more with the ethos of the art studio than of the factory—or of a factory “as it might be” [106].

This chapter traces the epistemic and material stakes of that claim. In what follows, I first describe the system of Imprimer and my role in its development. I then situate Imprimer in the broader context of digital fabrication research and material critiques of existing models of computation fabrication. From there, I examine the computational notebook as both an interface and an epistemic form, drawing connections to historical practices of inscription, experimentation, and collaboration. I argue that Imprimer is

not simply a novel interface for fabrication, but an example of how interpretative cultures—rooted in print and manuscript traditions—can reanimate computational practices toward more open, convivial, and participatory forms.

3.2 The System of Imprimer

Genesis of Imprimer

Imprimer emerged at the intersection of overlapping interests, existing expertise, previous work, and an understanding of existing limitations in current digital fabrication workflows. The project was initiated by Jasper Tran O’Leary, then a PhD candidate at the Machine Agency lab at the University of Washington, run by Nadya Peek. Jasper became interested in computational notebooks and, given his background in digital fabrication research, saw an opportunity to explore ways of integrating literate programming to CNC milling. A paper by Li et al. [89], published several years prior, presented a design system that allowed the maker to design toolpaths and directly dispatch them to a CNC milling machine. This project was similarly framed as an interactive alternative to more fixed, traditional CNC workflows. CNC workflows mostly follow a rigid, multi-step process, from CAD (computer-aided design) to CAM (computer-aided manufacturing), before executing machine operations. While this structure ensured precision and repeatability, it also creates barriers to experimentation and iteration, limiting the creative possibilities for practitioners beyond industrial contexts.

My own involvement with CNC milling had been shaped by several months of hands-on engagement and experimentation, particularly in mold-making from winter 2021 to winter 2022 (see Figure 3.1).

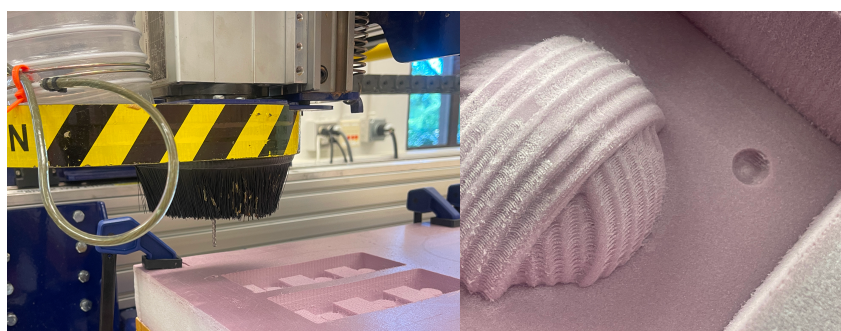


Figure 3.1. Mold making process using the CNC mill: making a negative mold in foam using the CNC mill.

I was using the Machine Agency lab’s CNC mill, a ShopBot PRS5 Alpha with a 96x60 work area. My process followed the traditional CAD-CAM pipeline: I would design the mold in Rhino [8] then generate toolpaths using the ShopBot CAM software called Vcarve (now Aspire), then dispatch the toolpaths to the CNC mill. My interactions with the machine were therefore heavily shaped by Vcarve—a software designed to ensure manufacturability over precision. Every time I ran a job on the ShopBot, I ended up with a material artifact that was more or less close to what I had in mind. I would then go

back to the Rhino file, make changes, export a .dxf file, import it in Vcarve, recalculate the toolpaths, and start a new job. This process did not encourage experimentation, and did not cultivate material intuition. Especially as a newcomer to CNC milling with no experience in subtractive manufacturing, I often had very little sense of how particular designs might turn out. The process of figuring that out required many steps, most of them spent in front of a computer looking at CAD or CAM files.

When Jasper suggested a collaboration to develop a more interactive way CNC workflows through computational notebooks, I was immediately enthusiastic at the opportunity to try a more flexible, iterative mode of making. Rather than adhering to the strict separation between design, documentation, and machine execution, we discussed a system where these elements could coexist dynamically within a single environment.

Over the course of the preceding years in the Machine Agency lab, Jasper and I had become acquainted with two “problems” of traditional computational fabrication workflows. First, many interactive digital fabrication tools offer limited options for direct toolpath manipulation and real-time feedback. Traditional CAM software treats toolpath generation as a fixed, one-directional process, leaving little room for live modification. This rigid workflow prevents makers from iteratively adjusting their designs in response to real-time material and machine constraints, limiting the capacity for creativity and adaptation. Second, conventional CNC workflows require practitioners to navigate multiple software environments, making it difficult to integrate documentation and iteration directly into the making process. The separation between CAD, CAM, and machine execution tools leads to inefficiencies, as designers must constantly shift between platforms and file formats, making it challenging to maintain a coherent and iterative design process. Moreover, literate programming was influential in the fields of data science and data-driven content production, but we saw an opportunity to extend this paradigm into fabrication, by allowing users to interactively program, document, and refine CNC processes within a computational notebook. By embedding machine control within a literate programming framework, we viewed Imprimer as offering a new paradigm for digital fabrication that aligns more closely with the iterative and improvisational nature of experimental making.

Overview of Imprimer

Imprimer is a system for CNC milling. I would argue however that, like all systems, it is also conceptual framework—a way of thinking about CNC milling that proposes a more reflective and iterative paradigm of interaction with CNC machines. In the paper presented at CHI 2022 [155], Jasper and I framed this paradigm as a shift from the maker-as-executor-of-programs to the maker as a *writer-of-programs*. This was a first step in conceptualizing what kinds of skills and knowledge were required to use open systems like Imprimer, which focus less on developing programming abstractions for usability and more on providing opportunities to wrestle with the complexity of the system. I later developed this idea further in a paper inspired by the work of French philosopher Gilbert Simondon, in particular his idea of technical mentality, which also considered the machine architecture and social organization needed for open systems to become the norm [137]. But before I go further into this discussion, here is a brief overview of how Imprimer works.

Imprimer integrates a computational notebook (built on Observable [113]) with direct machine control capabilities, allowing users to iteratively design, test, and refine toolpaths

within a live programming environment.

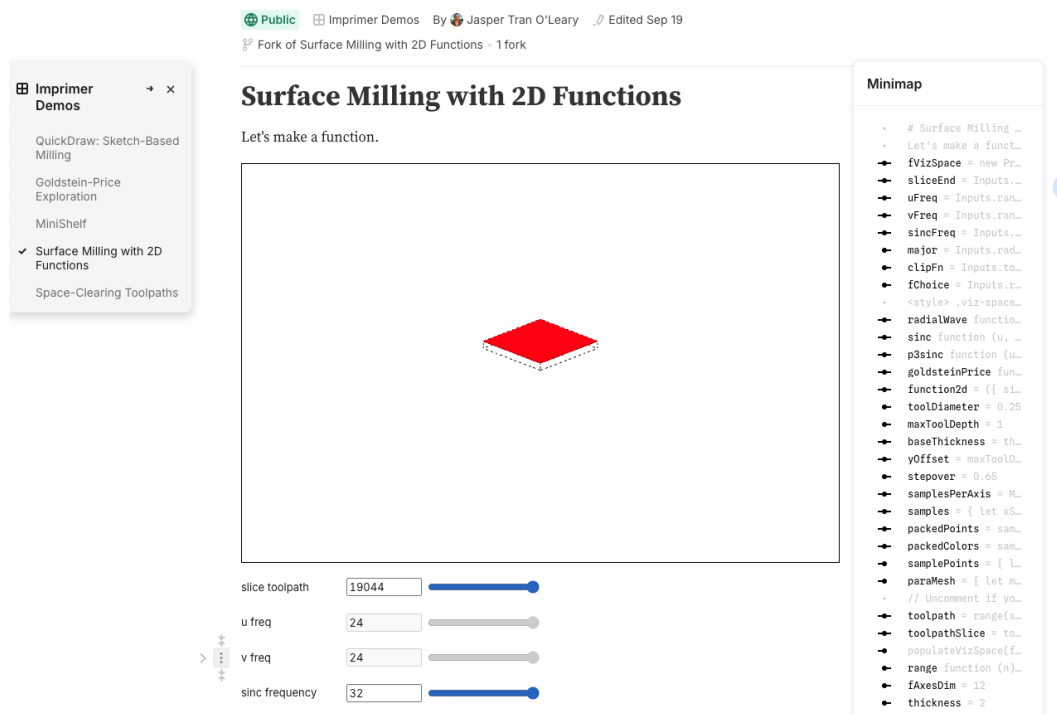


Figure 3.2. One of Imprimer’s notebooks, for surface milling using two variables functions. On the left, other notebooks of the same collection. On the right, a minimap of the various sections of the notebook.

By leveraging Observable’s reactive programming model, users can dynamically adjust parameters and see immediate visual feedback of their toolpaths, enhancing the design process (see Figure 3.2). The system also includes built-in support for parametric design, enabling designers to create customizable templates and modify geometry on the fly. Additionally, Imprimer supports real-time error checking and debugging, allowing users to interactively refine their milling instructions while maintaining a seamless workflow between code, visualization, and physical execution. The system enables users to send direct commands to a ShopBot CNC mill from within the notebook, eliminating the need to switch between separate CAD, CAM, and machine control interfaces. It provides real-time previews of toolpaths and milling parameters and uses a projection-based AR system, which overlays toolpath previews directly onto the machine workspace. This enables users to verify and adjust their designs before executing cuts. By interleaving documentation, code, and visualization, the notebook creates an accessible record of the design and milling process. One of Imprimer’s most significant contributions is its reframing of CNC milling as a live, iterative, and exploratory process rather than a strictly pre-planned execution of a finalized design.

Core Feature: The Computational Notebook

Imprimer’s most important feature—the computational notebook—is also its greatest “weakness,” at least in terms of usability. While embedding machine control within a literate programming environment allows for more direct machine feedback and built-in documentation, it does not make the process of CNC milling easier. If anything, Imprimer makes it more difficult—or rather, it requires more of the user, who needs to know how to program. The cells function as discrete, modular units of the toolpathing program and can be toggled on and off. This aspect of the interaction we discussed often with Jasper. The ability to toggle on the cells meant that the users could see the programs that generated the toolpaths sent to the CNC mill, and even change or modify them. Alternatively, the users could also decide to keep the cells toggled off, which hid the code, and simply operate the notebook like a GUI (see Figure 3.3).

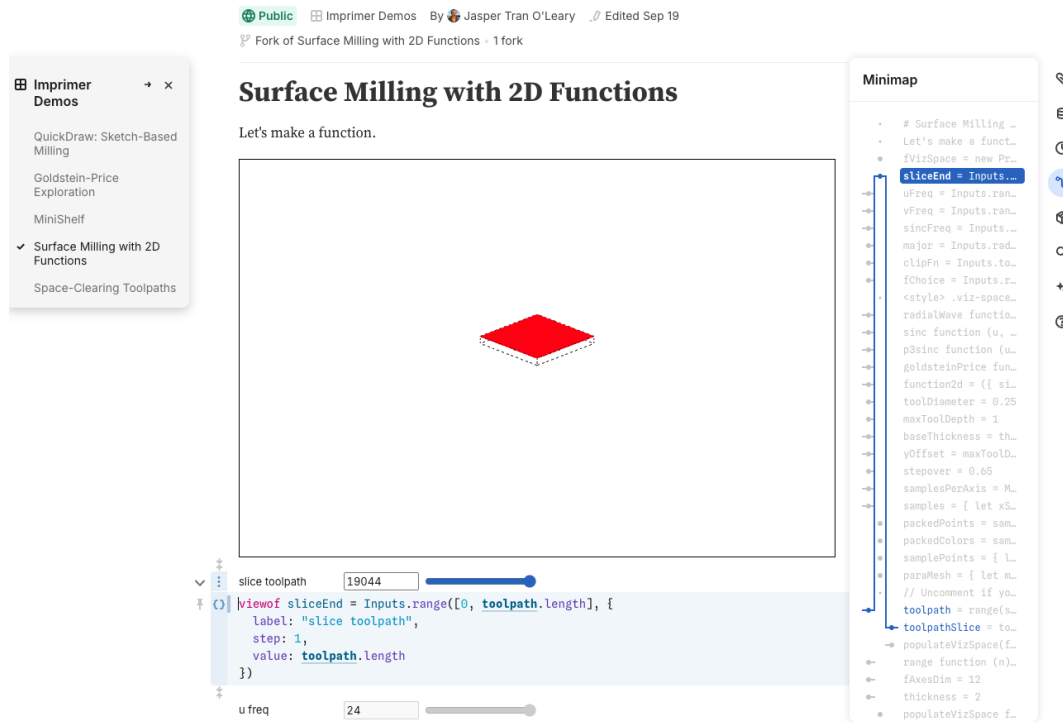


Figure 3.3. Same notebook as before, but the *sliceEnd* function has been toggled to reveal the code. The minimap on the right shows which variables this function calls.

For Jasper and I, this was a very interesting feature of the Observable notebooks. In traditional CNC workflows, operations are often hidden away into abstractions that are executed in a linear way. By contrast, Observable notebooks enable a more (inter)active and interpretative engagement with fabrication processes, where the maker can selectively reveal, modify, and recombine segments of code in real time. This granular control facilitates an iterative approach to machining, where toolpaths are not static directives but live inscriptions that can be rewritten, adjusted, and tested dynamically. Within

the discourse on seamful and seamless design in HCI [69], this would place Imprimer on the seamful end of the spectrum, deliberately exposing the mechanics of programs and machine operations rather than obscuring them behind an interface of frictionless automation. The ability to toggle visibility—to reveal or conceal the computational underpinnings of a fabrication process—foregrounds the epistemic stakes of making itself. Jasper and I saw an opportunity to embrace the contingencies of process, demonstrating how machine agency arises not so much from the seamless automation of machining, but from engagement of material, computation, and human intervention.

Yet, even between us two, the tension between complexity and usability remained variable. During one particular work session, Jasper started explaining how a user might operate a notebook for surface milling (for simplicity and legibility, each notebook controlled a particular type of job or operation, rather than having one very big notebook that could run multiple ones). He took a sheet of paper and started making calculations, to show how one might arrive at the equations necessary to write the program for this operation. I asked: “Are you envisioning this as part of the intervention? Is that what the user would need to do?” He paused, then said: “Ok, I’m glad we’re talking about this now.” It became clear that how the system was designed reflected some assumptions Jasper had on what users could do, based on his own abilities as a trained software engineer. I too started questioning my own assumptions about what users might know or not know. What might they know about programming? About Observable notebooks? About CNC milling? Could Imprimer be used by someone who knew nothing of any of these things? These are, in many ways, the fundamental questions of interaction design and HCI. We were discovering what it meant to make a system for yourself, for problems that you have encountered in your practice (in this case, CNC milling), and it is another to make it for other people, whose backgrounds, needs, preferences, skills, and access to resources might be widely different.

Yet we were working with a tool that afforded tremendous possibilities: the notebook. Complexity was definitely part of Imprimer, but it came alongside immense possibilities for annotation, documentation, and potential collaboration. In other words, the notebook made the system complex and simultaneously offered *a space* to engage with that complexity.

Imprimer reframes CNC milling as literate programming, interleaving documentation, visualization, and source code to encourage iterative experimentation. This strongly mirrors how historical notebooks—such as commonplace books, artists’ sketchbooks, and scientific lab notebooks—allowed practitioners to refine their thinking and document new processes over time. In the next section, I discuss the role of notebooks in my own practice, as well as historical cases, to illustrate how notebooks are tools that enable (and have always enabled) iterative and experimental thinking, material engagement, and collaboration. Through this discussion, I show that Imprimer draws on a long tradition of cognitive technologies such as notebooks that make thoughts visible and extends those capacities into the realm of material iteration. In doing so, Imprimer brings the mature technical schema of notebooks to digital fabrication systems.

3.3 Notebooks as Interfaces

“It is often useful to trace these figures and present them to the external senses in order to more easily keep our mind attentive.”

— René Descartes, *Rules for the Direction of the Mind*, rule fifteen, 1701 (my translation) [36].

The ‘technique’ referenced in Descartes’s fifteenth rule—the tracing of figures to make them present to the external senses—might seem to obvious as to seem trivial. It is in fact so common an act to the members of literate societies that it has become natural, which in a social context means that it has been integrated into culture.

The insight of the fifteenth rule is important however, as Bernard Stiegler has noted before, among others [145]: it is that thought, especially the more complex arguments required for the exercise of reason, is mediated through *material representations*. Drawings, diagrams, and notational practices all scaffold attention and extend human capacity to hold complex arguments [42]. This insight is also foundational to the development of computing [64]. In the specific case of digital fabrication, representation mediates between computational design and material realization. But while simulations and visualizations are artifacts that predict how machines will behave, interactions with materials always introduce unpredictability. The reality of physical constraints and contexts often complicate these abstract representations.

The problem of bridging representations and reality—words and things, to paraphrase Foucault—is older than writing itself. This was a concern of both Jasper (in the domain of programming languages) and I (in the domain of natural language), and Imprimer was developed in response to this. For instance, its augmented reality overlay provides real-time visual feedback of the milling process, addressing the disjunction between abstract design and physical execution. But this augmented view foregrounds only part of the representational challenge, and only the most visible part. It makes the material operation visible, but not the cognitive processes: ideation, reasoning, iteration, mental annotation. It is these processes that shape and determine machine operations in the first place, being in a constant dialogue with the materials. For that, we turn to the computational notebook.

Computational notebooks are hybrid media environments that weave together code, prose, and output in a single document. Computational notebooks are a popular example of literate programming, developed by American computer scientist Donald Knuth [80]. Knuth argued that the goal of programming should be to explain to humans what the program is doing: “Instead of imagining that our main task is to instruct a computer,” he writes, “what if we specify a method for communicating programs to human beings?” [80]. The main goal of literate programming is to treat computers programs as pieces of literature.

“During the 1970s I was coerced like everybody else into adopting the ideas of structured programming, because I couldn’t bear to be found guilty of writing unstructured programs. Now I have a chance to get even. By coining

the phrase “literate programming,” I am imposing a moral commitment on everyone who hears the term; surely nobody want to admit writing an illiterate program.” [80]

While this comment can be read as a playful jab to the normative tendencies of computing ideas, the “moral commitment” Knuth pushes forward through the idea of literacy in programming indeed refers to an orientation towards what we might call *legibility*, which is one the premises of openness in technical system as I conceptualized it elsewhere [13]. Knuth’s goal was to make computing not just operational but, we might say, legible, even interpretive, aimed at clarity and reflection as much as execution.

This orientation is at the heart of the most well known and widely adopted computational notebook platform, Project Jupyter [75], initiated by Fernando Pérez and Brian Granger in the early 2000s. As Pérez recalls, he wanted a unified environment that could combine notes, code, graphics, and output—an “interactive computing environment” for scientific work. This ambition resulted in what we now call the Jupyter notebook, which developed into an entire ecosystem, comprising “a file manager, a text editor, a terminal emulator, a monitor for running Jupyter processes, an IPython cluster manager and a pager to display help” (as reported in [131]). The Jupyter ecosystem exemplifies what Schultz calls an “intermediary support,” that is a medium situated between scripts, outputs, and explanatory narratives, and used by a diverse range of communities [131]. The power of computational notebooks indeed lies in their compound format: they serve simultaneously as sites for writing code, executing it, viewing its output, and annotating the reasoning or operations behind it. This co-presence of process and output makes the notebook a tool of documentation of process—that is, of thinking itself. In their study of over one million notebooks on GitHub, Rule et al. found that while many notebooks lack detailed explanation, analysts nonetheless use them for highly personal and exploratory work, often messy, nonlinear, and rich in implicit decisions [127]. In this sense, the notebook’s flexibility and extensibility—not only its capacity to accommodate a variety of content and media but also to interface with other systems—are its strength. The notebook accommodates both iterative experimentation and (eventual) narrative construction, even when the two remain in tension (as they often are).

Indeed, Pérez’s motivation for building Jupyter reveals a deeper value system. He notes that using closed, proprietary tools to investigate natural phenomena felt incoherent: “I think of science’s mission as opening the black box of nature. It’s a bit nonsensical to do that with tools that we are not allowed to open and understand” (as reported in [131]). Here, Pérez links the legibility of tools with the legibility of nature itself, asserting that epistemological transparency in science requires technical openness in its instruments. Pérez’s statement points to a broader and more political claim: that open tools foster open inquiry. The computational notebook is open by design, inviting modification, supporting heterogeneous practices, and sustaining a culture of experimentation and open sharing of experiments. As I will argue in the following sections, this extensibility is not a novel feature of computational notebooks but a continuation of the affordances of their analog predecessors. Notebooks, both digital and analog, are technologies of externalized cognition. They shape how ideas are developed, and notebooks have long served as capacious and flexible media for iterative and exploratory thought. What computational notebooks offer is an amplification of these qualities: they retain the affordances of inscription, annotation, and juxtaposition, while adding computational legibility and

machinic extension.

This section has argued that notebooks are interfaces for open-ended thinking, and that they are themselves open tools, representational systems that mediate between conceptualization and execution, between humans and machines. From Descartes's *Rules for the Direction of the Mind* to Knuth's literate programming, to Pérez's development of a tool that could support his doctoral work, thought is revealed less as an internal process than as an operation that is structured, extended, and made legible through external representations. Computational notebooks embody this principle of legibility and extend it further, embedding code within narratives, enabling outputs to sit alongside ideas, and allowing the medium itself to be modified and extended. In this sense, notebooks are open by design: open to interpretation, open to modification, and open to connection with other media and systems. In the next sections, I turn to this openness in practice: how notebooks function as flexible, extensible environments for iterative thinking, material engagement, and collaborative knowledge production.

3.4 Notebooks as Sites of Exploratory Thinking

There are so many examples of how notebooks enable iterative thinking that several books would be required to catalogue them. Indeed, many such books exist, from facsimiles of Leonardo da Vinci's codices to carefully edited volumes on the notebooks of contemporary artists. Collections like these reveal the range of what a notebook can hold: sketches, diagrams, material swatches, photographs, clippings, scattered thoughts, and meticulous indexes. They show how the page can accommodate layers of thinking, returning to an idea days, months, or years later to add, revise, and connect.

In the spirit of this dissertation, I turn to my own practice, since notebooks are a key dimension of my creative and research work. My notebook practice is digital and analog system spanning multiple media, such as note-taking software; vector and pixel-based drawing applications; voice transcription software; and analog materials, such as bound notebooks, loose sheets, pencils, pens, stickers, glue, paper fragments. This constellation has been recently extended further by machines such as the pen plotter, which allows digital configurations to be expressed on the physical page in a precise yet open-ended way.

My Notebook Practice

Notebooks are an integral part of how I structure my thinking, daily experience, as well as my research and creative practices. Instead of focusing on one single project, I want to give an overview of how various writing and note-taking tools are integrated in my creative and research practices. My goal is to show how my thinking and material investigations are supported by various inscription technologies. By turning to my own practice of keeping a notebook, I wish to make visible the tacit, often ineffable dimensions of how thought unfolds, capturing the micro-decisions, hesitations, dead-ends, and latent connections that might be lost in third-person analyses.

My notebooks are both the object of study and the method of inquiry. As such, they are experiments in the epistemological commitments I profess—to understand knowledge as enacted rather than pre-existing.



Figure 3.4. Notebooks from 2016-2017. The notebooks feature a mixture of handwritten notes, diagrams, schematics, material samples, and material index.

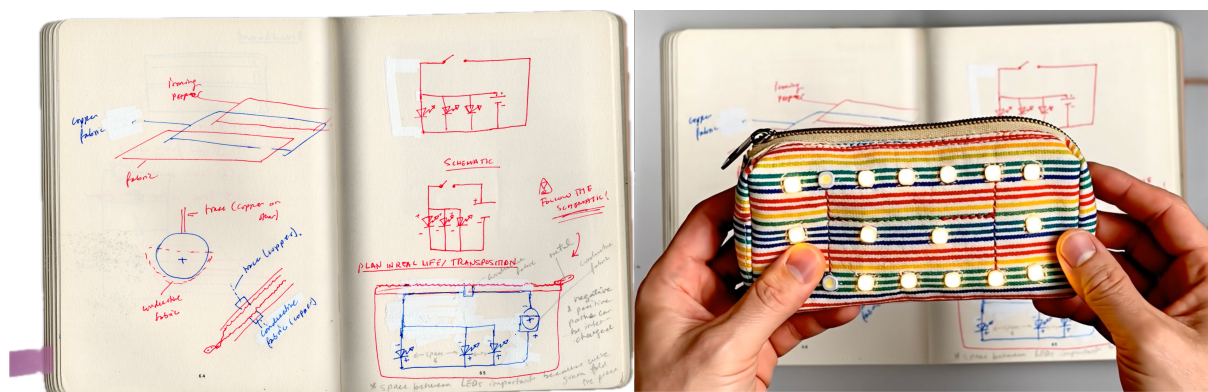


Figure 3.5. Left: page from one of my notebook, with the rough schematic for an e-textile pencil case, with a zipper switch and LEDs sewn in parallel. Right: a representation of the resulting artifact (Note: the image on the right is AI-generated based on a sketch of the original artifact).

Consider for instance these pages from notebooks kept in 2016-2017 when I was a masters' student at the University of Washington and learning about the field of e-textiles in Professor Afroditi Psarra's course. They capture the range of materials that can co-exist in the notebook: schematics, diagrams, handwritten notes, list, taped-in swatches of conductive fabric, a material index. My practice of keeping a notebook, of externalizing thoughts through writing, sketching, and diagramming, aligns with Merleau-Ponty's argument when he writes:

“There is no such thing as a thought that is fully thought and does not call upon words as the means to be present to itself. Thought and speech anticipate one another. [...] Effective speech makes one think, and living thought magically finds its words.” [104]

Merleau-Ponty suggests that thought is not fully formed in the mind before expression but emerges in the enaction of language. Thought, in other words, depends on the conditions of (material) expression, rather than the other way around. Artist Patricia Cain's investigation of her drawing practice similarly emphasizes that thinking is a process that unfolds through material engagement [19]. Cain builds on Francisco Varela's notion of enactive cognition, which states that cognition is enacted in the ongoing interaction between brain, body, and environment, rather than residing solely in the mind [160]. Distributed cognition extends these ideas by highlighting that cognitive processes are spread across people, objects, and tools in the environment. If writing and drawing are modes of cognition, then the tools that enable them are means of structuring thought through movement, iteration, and response to the material world. In my own practice, I can see that my thinking is informed by the artifacts I use.

In the last year, my notebook practice has further spilled out of the page through the introduction of a machine: a pen plotter, which is a type of specialized printer used for producing high-precision vector graphics. Unlike regular printers, which use a raster-based approach, plotters draw continuous lines with a pen, blade, or other tool (see Fig. 3.6). The plotter allows me to bridge the digital-physical gap by maintaining all the affordances of digital note-taking (archiving, indexing, flexibility) and the embodied dimension of physical notebooks. I started writing my journal entries in a vector application, which I would then send over to a plotter via another vector graphic software, Inkscape. Sometimes, I would write notes directly in Inkscape and send them over directly to the plotter.

What is the importance of exploring all these note-taking tools? The practice of keeping a notebook is akin to having a portable laboratory where data can be collected, organized, annotated, and (re-)used for various projects and purposes. It is also a space where thinking can become more exploratory, and where traces of thinking processes can be captured. The *format* of the notebook plays an important role in that process. The notebook is a very mature technology which allows flexibility while supporting many different types of operations. The notebooks of French painter Fabienne Verdier are illustrative of the capaciousness of notebooks (see Fig. 3.7). Verdier uses her notebooks as visual and conceptual laboratories where she can document and explore associations, data and ideas, as I discuss in the next few paragraphs.

In *How the Page Matters*, Bonnie Mak writes that the page is both a conceptual and material construct [97]. In scrolls, the *pagina* (a conceptual unit) was used to organize



Figure 3.6. A sequence from my notebook-to-plotter workflow: plotting generative drawings, translating digital sketches onto paper, making texture and color tests, experimenting with scale, and layout.

information in a way that required manual navigation, while in codices, the material page and the conceptual page became more closely aligned. The page acts as a discrete unit of thought, providing a certain regularity despite the wide variety of content it can accommodate. Whenever new tools enter the notebook workflow, this tool also becomes part of the experimental and iterative process enabled by notebooks. Notebooks are effective tools for exploratory and iterative thinking because they are “open,” that is they are easy to modify, customize and extend [13].

My notebook practice is not unique however: scientists, writers, craftspeople, and artists, among others, have long relied on notebooks for both exploration and documentation. As is often the case however, artists have a way of pushing the limits of a media in ways that reveal the processes facilitated by them. It is in this expanded sense that artists such as Fabienne Verdier and Anni Albers engage with their notebooks, approaching the page as a structured and tactile space integral to the meaning of the work itself.

3.5 Notebooks as Sites of Material Engagement

As the previous section showed, notebooks are places where the material dimensions of work get tested and rehearsed. No matter the outcome (text, textile, machine) or the field, notebooks offer a low-stakes, open frame for exploring what materials can do before those explorations become finalized. Notebooks show that the act of making is inseparable from the act of thinking.

Fabienne Verdier

French painter Fabienne Verdier was trained in Chinese calligraphy for 10 years and makes extensive use of notebooks in her work to explore both formal and theoretical elements of her paintings. Her series of notebooks titled *Ainsi la nuit* offer an example of how notebooks are used to iterate both conceptually and materially. Each page (or planche) is a self-contained composition that integrates textual notes, color swatches, diagrams, and clippings from other sources. On *Planche no. 6*, for instance, fragments of printed imagery are taped alongside diagrams and brush tests. Strips of color test the luminosity of pigments and fine-lined sketches explore spatial arrangements. Handwritten notes record ideas and reflections about the paintings' theme [164].

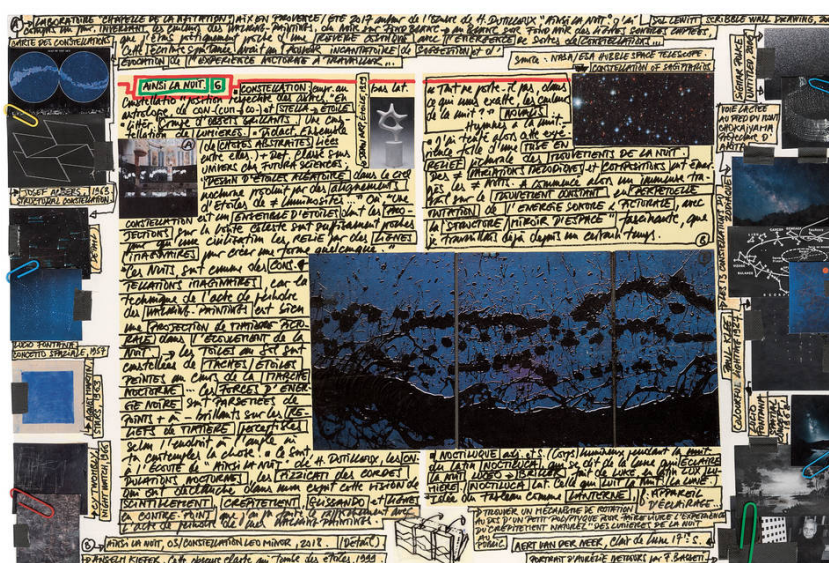


Figure 3.7. French artist Fabienne Verdier's notebook page for the series *Ainsi la nuit*. Image from the artist's website.

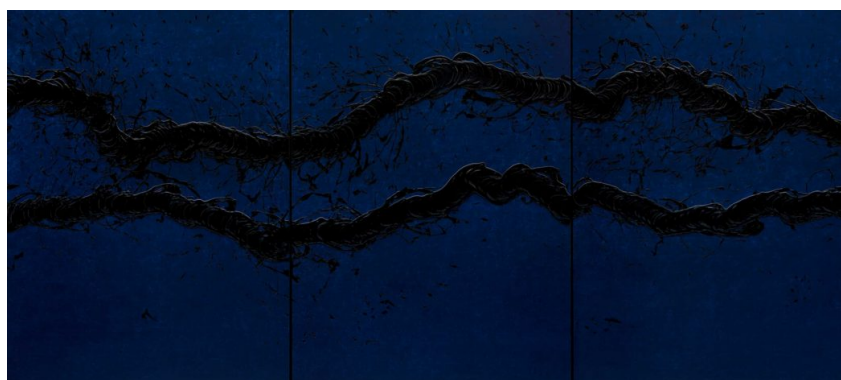


Figure 3.8. The work *Corona Borealis* by Fabienne Verdier, 2018. Part of the series *Ainsi la nuit*. Image from the artist's website.

This tight coupling of material and conceptual inquiry resonates with my own pages where, for instance, a circuit diagram is next to swatches of conductive fabric, or a plotted test print is taped opposite handwritten reflections on pen pressure. In each case, the notebook functions as an *interface* through which thoughts and forms find their expression in materials. It is in the open-ended and cheap space of the notebook and its adjacent swatches that affordances are discovered: the effect of the certain colors' arrangement, a pen plotter's habit of dragging ink on certain papers.

Anni Albers

Although only one of Anni Albers' notebooks has survived in its entirety, it shows how material engagement begins at the level of sketching and notation [3]. Albers, a German weaver and artist who attended the Bauhaus in the 1920s and later taught at the Black Mountain College in North Carolina, used this particular notebook towards the end of her life to explore weaving structures, sketching patterns and forms that would later materialize in her textiles, as well as her prints. The sketches, made on graph paper, reflect her approach to textile design through an exploration of structure and material properties [2].

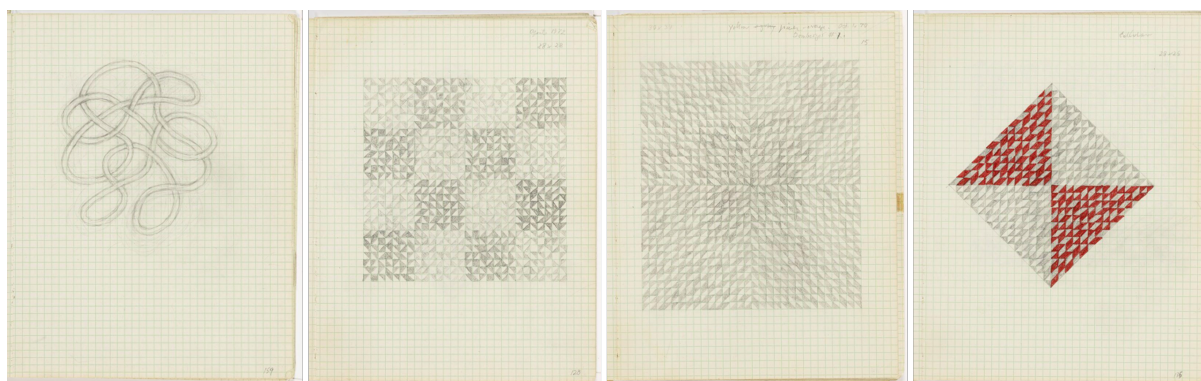


Figure 3.9. Pages from Anni Albers' notebook, 1970-1980. Part of the Josef and Anni Albers Foundation.

In a review of the publication of her notebook by publisher David Zwirner Books in 2017, Lara Kuykendall notes how Albers' designs unfold through subtle variations in pattern, where “limitations—to graph paper and pencil, pen, or a single color—and decisions—beginning with a line or a shape, repeating, alternating, or altering—can yield revelations in abstract form” [83]. These “limitations” were well known to Albers, who wrote in 1944 that crafts are “traditions of operation which embody set laws” [2]. While these laws can be constraining, they also provide “a discipline” which balances the momentum of creativity. This is good, according Albers, who outlines through this observation the tension between material constraints and creative impulse. Limitations are productive, in other words, but only if the tools enabling engagement with these limitations simultaneously offer possibilities for creative experimentation. How engagement with complexity is either facilitated or constrained by tools is a key issue in the design of fabrication systems, and notebooks present an interesting parallel: while being a space

of creative exploration, they also impose certain “material limits,” such as the page, as previously mentioned.

What makes Albers’ notebook particularly illuminating is that it captures a process of abstraction that is deeply material. The transition from textile to printmaking in her later years is testament to the fact that her approach to working with material, whether thread or ink, remained consistent. While Albers’ practice did not involve numerical control or computation, we can say that her work was “machine-adjacent,” since her loom functioned as a technical apparatus that required precision and skill, yet it also allowed for improvisation within constraints. The notebook, in this context, was a preliminary machine of sorts: a way to externalize and refine her engagement with material before committing to the labor-intensive process of weaving or printmaking.

3.6 Notebooks as Sites of Collaboration

In the preceding sections, I have shown how notebooks support iterative and experimental thinking, as well as their role in material inquiry. Another key affordance of notebooks is their function as sites of collaboration. Because of their capacity to structure and document ideas, notebooks have long facilitated shared knowledge production, whether through marginal annotations or correspondence [4]. This collaborative dimension is key to the epistemic role of notebooks; they are, besides cognitive laboratories, also means of communication and exchange of ideas.

For Imprimer, this function is extended. Computational notebooks, unlike analog notebooks, can be forked, modified, and shared in real time, which facilitates their dissemination as living documents. While notebooks can be intimate, they can also be public, and serve as starting points for others to modify and extend. This is particularly true of computational notebooks. Like code repositories, computational notebooks allow multiple contributors to edit and refine workflows. Especially in the context of toolpath generation, this is fairly unprecedented, as toolpaths tend to live in proprietary software and exist on individual hard drives. With computational notebooks, users can build upon prior work in a way not dissimilar to how the platform OpenProcessing fosters communal iteration on creative coding sketches [116]. In this way, the computational notebooks of Imprimer can be generative spaces for collective material inquiry.

This openness is particularly significant in the context of CNC milling, where conventional workflows are often rely on abstractions that conceal the complexity of machine operations. Typically, toolpath generation remains hidden behind proprietary software, which limits visibility into the decisions that shape the artifact. With Imprimer, however, toolpath design, material considerations, and fabrication constraints are all documented within the notebook itself, allowing for a more transparent, interpretable, and participatory mode of machine control. Compared to other, more “traditional” CNC milling workflows, which treat the milling process as a closed-loop system where only the final design matters, Imprimer makes visible the incremental modifications and reasoning behind fabrication choices (the programs). This openness has the opportunity to support collaboration between individual makers, and potentially foster broader communities of practice. Because of the shareable and extensible nature of the computational notebooks, other makers can actively participate in the evolution of the designs and programs, as

well as the thought processes visible in the notebooks. Instead of downloading a static G-code file, for instance, users engaging with an Imprimer notebook encounter an editable, modifiable system that invites experimentation and customization.

This quality positions computational notebooks within a lineage of open, interpretative tools that scaffold and shape making—a lineage that stretches from paper notebooks to literate programming environments.

Notebooks, as I have argued, are not just interfaces for documenting thinking and material processes but interpretative tools that are always already part of material workflows. This leads me to the central argument of this chapter: by leveraging the capabilities of computational notebooks for CNC milling, Imprimer does not simply present a novel control interface for fabrication but *extends* the exploratory space of the notebook to the machine itself, which then acts as an extension of the notebook—embedding iterative, experimental, and collaborative capabilities directly into fabrication processes. In the following section, we will explore how this paradigm shift blurs the boundary between thinking and making, turning the CNC mill into a kind of machinic notebook.

3.7 Notebooks as Machines / Machines as Notebooks

Throughout this chapter, we have seen how notebooks operate as sites of iterative thinking, material inquiry, and collaboration. Traditionally, the notebook has been understood as an intermediary tool, a space where ideas take shape before they are executed elsewhere, whether in the form of an article, an artwork, a system or an artifact. But what happens when the notebook is directly integrated in a material production workflow? This is the shift that Imprimer introduces: rather than treating the computational notebook as a detached (or detachable) interface for CNC milling, it embeds machine control into the notebook itself, effectively transforming the CNC mill into an extension of the notebook's experimental and iterative affordances.

As we have seen in the previous sections, the design and format of the notebook are integral to its function as a space of conceptual and material exploration. The material conditions of writing, sketching, and diagramming, in other words, shape the possibilities of thought itself. This insight is crucial in the context of digital fabrication. The computational notebook is not just an interface for issuing machine commands but a space where material engagement is structured, documented, and refined. With Imprimer, the programmatic and machine operations of the CNC milling process becomes visible and extensible, that is, *interpretable*. Instead of being an opaque sequence of machine commands conducted through proprietary CAM software, machine operations become part of the experimental space of the notebook. This realignment brings fabrication workflows closer to the historical function of notebooks as both representational and generative tools.

One of the fundamental challenges of CNC milling when it comes to creative work is that it is traditionally a production-oriented process, and therefore has been designed for efficiency, precision, and repeatability. In contrast, notebooks have historically been experimental spaces, places where errors, revisions, and iterations are encouraged. By embedding CNC machine control within a computational notebook, Imprimer merges the affordances of both notebooks and CNC machines. Imprimer turns the CNC machine

into an interactive system where toolpaths are modifiable programs that can be tested and refined dynamically. If notebooks have historically been used to externalize thought, then Imprimer extends this function through the machine itself. It shifts the CNC mill from a tool that receives pre-planned instructions to an instrument within a recursive, evolving notation system. Just as literate programming provides a single space for both documentation and execution, Imprimer provide a space for both thinking and making, for notation and fabrication. The modularity of computational notebooks allows users to document processes as they program and execute them, modify toolpaths with the feedback of rapid iteration, modify parameters without having to regenerate or re-import files, which all facilitate the process of experimenting with machine control, and treat it as a *process of material inquiry* rather than simply as the process of executing design.

What Imprimer ultimately suggests is that writing (programs, notes, explanations) and fabrication are intertwined practices. Just as the notebook has historically been a thinking tool, it now becomes a machinic tool. This reconfiguration has significant implications for how we understand digital fabrication. Rather than reinforcing the traditional hierarchy of design over execution, Imprimer foregrounds the CNC mill as an active participant in an ongoing conversation between the maker, their notations, the materials, and the machine.

3.8 Conclusion

Through the case of Imprimer, this chapter has traced how computational notebooks inherits their open design from their analog predecessors as sites of iteration, material engagement, and collaboration, extending the epistemic and material affordances of traditional notebooks into digital fabrication.

At its core, Imprimer challenges conventional notions of digital fabrication by foregrounding *interpretation* as an integral part of making. Interpretation happens through the writing of programs and notes in the notebook and the continuous back and forth between the maker and the CNC milling machine's operations. Beyond the technical contributions of Imprimer, which were laid out in the proceedings presented at CHI in 2022, I wanted to talk here about its epistemic contributions, as a system that views "fabrication as writing programs—not just executing them" [155]. Imprimer is an illustrative case study because it reimagines fabrication through a hermeneutic lens that acknowledges the importance of iteration and material dialogue, while supporting grappling with the "ungrammatical" moments between human and machine: when the program does not compile or when machine operations does not happen as planned. By situating computational notebooks within a broader lineage of inscription technologies, such as notebooks, Imprimer is an invitation to reconsider the epistemic stakes of digital fabrication as a space where making, writing (text, code), and thinking intersect.

CHAPTER 4

Writing with Data

4.1 Introduction

We are surrounded by data; data accumulates in ways both deliberate and unintentional, captured by smart home devices, search engines, social media platforms, and countless other systems. Yet, if asked, most people would struggle to describe what their own data looks like—where it resides, how it moves, and what stories it tells. This chapter looks closely at a multi-year project during which data produced via smart home devices were turned into fiction stories. The Data Epics project looked specifically at “small” data, a scale at which data is considered almost negligible, too specific to yield any insights or “patterns,” to show any real trend. Yet, most of the data we produce live in these “long tails,” born out of the always specific and situated contexts of every day lives.

This chapter is about the hidden life of this data. It explores an experiment in making personal data tangible, interpretable, and able to be experienced on a narrative register, through a project called the Data Epics. The Data Epics reimagined how personal data might be construed as material for narratives, and how this approach to data representation might foster new data imaginaries. By pairing fiction writers with smart home data collected from real households, the project sought to explore what data could become when experienced on the textured and equivocal register of fiction. What kinds of stories might be told from data traces that are usually only computed by algorithms? How might those stories reframe the way data producers think about the digital remnants they leave behind? The project emerged from a broader set of questions about the materiality of data, its interpretative flexibility, and the cultural imaginaries that shape how we understand digital information. In this chapter, I describe the project’s motivation, process, and findings, exploring how data fiction serves as an alternative mode of engaging with personal digital traces. In particular, I focus on one story, *Hi! How Can I Help?*, a narrative that unfolds from the perspective of a voice assistant. This story, like many in the project, illuminates the tension between human and machine interaction, but mostly shows that the perspectives of data are always both obscure and illuminating—and that fiction is one of the most accommodating medium to explore such tensions. In this chapter, I explore how data fiction functions as a means of material engagement, and how data, when reinterpreted through fiction, can challenge existing assumptions about what data is and how it works, as well as enable interpretative participation. In doing so, I extend the discussion of literary interpretation as a mean of material engagement discussed in Chapter 2, and position Data Epics as an example of an interaction modality that fosters more critical and creative encounters with personal data.

The Data Epics challenge the mainstream belief that data is a reflection of reality.

Instead, the project shows that data is always a site of interpretation, a material for making meaning, and a generative space for speculation. Just as myths and epics have long shaped how humans make sense of the world, perhaps data fiction can offer an alternative mean of understanding increasingly datafied live—not as an immutable record but as an open-ended story still being written.

Data as Material

The previous chapter considered material engagement in the context of digital fabrication. But materials are not limited to physical substances such as wood, metal, or fiber; their physical properties can be more subtle, as if the case of sound in the context of a music practice, or of space and time in the context of cinema. In fact, materials themselves have imaginaries; what counts as a material is socially constructed, as exemplifies any 2 foot x 4 foot sheet of plywood, a designed and highly processed artifact that is nonetheless considered a material [92]. Here, I extend the discussion on interpretation in the context of material engagement by positioning data as a material. The notion of data as material has gained traction within design research [156, 86], bolstered by the shift from the positivist view of data as an objective, neutral representation of reality toward a more situated, constructed, and interpretative approach. Works such as *Data Feminism* by D’Ignazio and Klein [32], *Technologies of Speculation* by Sun-ha Hong [66], *All Data Are Local* by Yanni Loukissas [93] and Johanna Drucker’s humanistic approaches to graphical display [45] show that data is inseparable from the tools, systems, places, and narratives that make them. The Data Epics build on these ideas, and demonstrate that data can be further transformed not just with the tools of data science but with the techniques of fiction, and through this process become more accessible, malleable, and open to reconfiguration.

Overview of this Chapter

Here, I explore the specifics of data representations through a close reading of one of the Data Epics, the story *Hi! How Can I Help You?*, written by Alma García.

While all the Data Epics wove data within their narrative, some in obvious ways, others in a more subtle manner, *Hi! How Can I Help You?* was a clear example where data provided the material not just for the story’s plot but for its atmosphere and texture as well. The Data Epics follows a long tradition of narratives that decenter human consciousness as the primary organizing principle of storytelling. From the object-oriented stories of 18th century “it-narratives”, where inanimate objects serve as narrators or focal points, to 20th century poetry about the accumulation of objects in modern life [120], to new materialist texts [16, 10], and the ecological narratives that privilege non-human perspectives [121], there is a rich body of literature that challenges anthropocentric literary conventions [71, 100].

What distinguishes the Data Epics within this tradition is that fiction is used here as a mode of data representation, rather than as a narrative perspective or persona. At the start of the project, García admitted that she had never done this kind of writing before, where the main protagonist is not a human. Through the story, the reader can sense the writer working through narrative perspective to understand the identity or nature of the story’s narrator—to understand the relationship between data and device, and between

device and humans. More importantly, García weaves the non-human narrative voice within the very human dynamics at the core of her story. Whereas other excellent stories within the Data Epics featured equally strong data narrative voices (as in *The other fish* by Alex Madison, or *Intelligence* by Joshua Marie Wilkinson, to name just a few), the relationship between machine and human voice(s) are more prominent in *Hi! How Can I Help?*

4.2 Expanding Data Imaginaries

The Data Epics sought to expand data imaginaries, and did so by reconfiguring interactions with domestic data. The project was initiated by designers Audrey Desjardins and Heidi Biggs with one writer and one home dweller from the Seattle area [38]. This pilot study was published and presented at the ACM CHI conference in 2021. The initial study concluded: “We see the Data Epics as the start of a journey into more nuanced, messy, lively and situated ways of seeing data. While we thought the Data Epics would be about data leaving and returning home, and about the mystical things that might happen elsewhere, we now see they are part of a larger (epic) research agenda to make data come alive and understand how they are entangled in the lives of people living with domestic IoT” [38]. This larger, and perhaps epic, research agenda was partially carried out over the course of 2021 to 2023 in the form of a more extended version of the pilot, with seven writers and thirteen home dwellers.

The Data Epics came in at a point in my research journey when I began questioning the relationship between computation, materiality and interpretation. Through a series of projects on speculative machine learning [12, 39] and digital fabrication research [14, 65], I was starting to conceptualize that interpretative activities were playing an important role in interactions with computational systems. In the context of fabrication, the constant back and forth between materials, tools, actions, and outcomes was very similar to the kind of creative selection that was required of textual analysis. More importantly however, the relationship between computational representations and their physical analog (between “words and things” to paraphrase Foucault once more) seemed to be the gap where things tended to become “ungrammatical,” or mystical, and which was therefore worth investigating further. Given the Data Epics’s focus on two expressions of computation and interpretation I had not yet explored—data and fiction—it seemed like a wonderful opportunity to get involved in a more extensive design research project and to keep exploring the relationship between computational artifacts and their representation.

Data Imaginaries

Central to the project was the idea of data imaginaries. The project sought to question and expand dominant sociotechnical imaginaries of data, often narrow and unidimensional: ones and zeros, green script on a dark screen, fast traveling packets of information through abstracted tubes. Drawing from Jasanoff’s and Kim’s concept of sociotechnical imaginaries, defined as collectively held visions of desirable futures shaped by science and technology [72], the project used as its starting point how data is typically framed within a technological discourse of abstraction and optimization, and especially the elimination of uncertainty. In the words of STS and media scholar Sun-ha Hong:

“At the level of data as a broader, popular imaginary ... is the enduring popularity of a rather naïve extrapolation of Shannon’s law of information: the idea that we can progressively eliminate uncertainty in all situations through the addition of information (which are themselves certain), each of which would reduce uncertainty in varying amounts. Both as a technical procedure and as a social imaginary, datafication thus consists not simply of truth claims but also the normalization of a new kind of grounding for knowledge claims.” [66]

Hong describes the material conditions for producing knowledge with and through data, which involves automated capture and digital processing. Not unlike Daston and Gallison [34] before him, Hong observes that because the means of capturing phenomena are automated, the representation of phenomena—data—seems more objective. However, critical perspectives from feminist data studies, information science, and the digital humanities, among others, have problematized this view. For instance, D’Ignazio and Klein demonstrate that data is always situated: it emerges out of particular contexts, social relations, and power dynamics that shape both what gets counted and how it gets interpreted [32]. Similarly, Johanna Drucker’s work in comparative media studies argues that the meaning of data cannot be understood as inherent or self-evident. Like all meaning, it is a property of relation and emerges out of interactions between data, format, and reader [43, 45]. Lisa Gitelman further supports this view that data is never truly “raw” but always processed through human and institutional frameworks further undermines claims to data’s objectivity [54]. These perspectives show that the apparent neutrality of data obscures the many social and interpretive processes that constitute datafication. By transforming data into fiction, the Data Epics sought to demonstrate how data is always already an interpretative act—or in the words of Drucker, an event [41]—rather than a stable unit of information. As such, the Data Epics takes a feminist approach to data collection and manipulation; rather than seeing data as knowledge artifacts, the Data Epics aimed at reconnecting data “back to the context in which they were produced” [32, p. 152]—but with a (narrative) twist. The Data Epics puts a speculative spin on this feminist approach by reconnecting data to their context of production while simultaneously proposing vignettes into alternative contexts of use, narratives, and data worlds. Rather than trying to recreate the context of the datasets, the Data Epics sought to *reconfigure* these contexts and the data themselves through fiction.

Fictionalizing IoT Data

IoT data is an interesting type of data as it is simultaneously intimate and distant. Produced within the familiar boundaries of the home, it is nonetheless rarely experienced on an intimate mode. More often than not, it mostly remains an invisible phenomenon. While individuals interact with smart devices daily, whether through voice assistants, motion sensors, thermostats, smart beds, or other networked devices, the underlying data collection processes remain largely opaque. These devices generate an extensive record of human activity, yet this data is rarely presented to the data producers in ways that invite interpretation and participation. Rather, data is often visualized in more prescriptive forms [67]—what Drucker calls “realist or mechanistic” data representation, such as dashboards and graphs, which tend to obscure the material, historical and ideologi-

cal conditions of data production [45]. The Data Epics emerged as a response to these approaches by proposing an alternative way to engage with personal data through fiction.

4.3 Making the Data Epics

The team working on the Data Epics changed and fluctuated over the course of the project as undergraduate and graduate students from the Design department at the UW joined Audrey and I through quarterly Directed Research Groups, for data analysis, organizing the public reading event [148], and building the website for the project [153], among others. Stephanie, as Master’s student in Design, worked with Audrey and I to collect the data, format it, create the data visualization and the booklets, and interview the writers and participants after each story cycle. The stories were created through a structured process following the steps described below. In total, we repeated this cycle four times, between March and April 2021, May and June 2021, August and September 2021, and November and December 2021.

Data Collection Participating households recorded data from their smart home devices for a month at a time. Participants chose in advance which device would be used for that cycle of data collection. Once collected, the data was exported into various formats, including CSV files, text logs, and audio recordings. The devices in use included voice assistants (Amazon Alexa, Google Home), smart thermostats, smart bulbs, and security cameras, among others.

Data Processing and Interpretation The research team anonymized and formatted the collected data to make it more accessible for the writers. Simple visualizations were created to highlight patterns in the data. The research team then shared the data with the writers alongside a prompt to guide the theme of the narrative and additional literature to inspire the writers.

Creating the Stories Each fiction writer crafted short stories based on the datasets they received. While some stories used the data explicitly—embedding specific timestamps or sensor readings—others took a more interpretative approach, using the data as inspiration for broader themes, moods, and narrative structures.

Sharing the Stories The completed stories were printed and assembled as hand-bound booklets and sent back to the participating households. This tangible, crafted format contrasted with the often-immaterial nature of digital data, and reinforced the project’s emphasis on the materiality of data.

Reflection and Discussion After receiving their stories and reading them, participating households were interviewed about their experiences (about a week later). These interviews provided insight into how individuals perceived their data before and after reading the story. Similarly, writers were interviewed after they completed each story to understand their reaction to the dataset, their way of working with it, and how the data inspired the stories.

Through the Data Epics process, data started as one kind of phenomenon and was

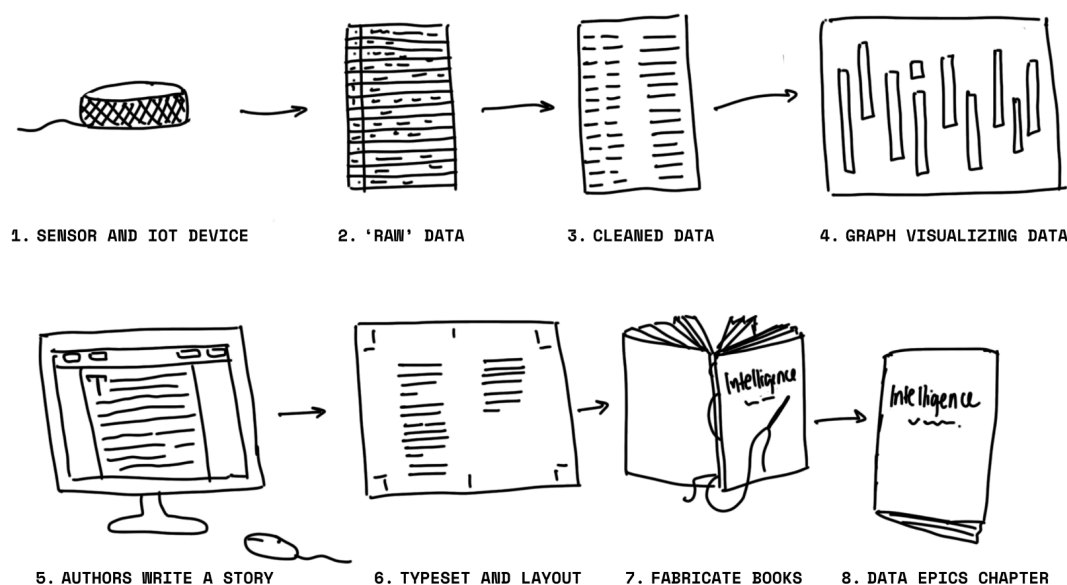


Figure 4.1. The Data Epics process: From IoT device data to bound booklet

transformed into another. On the most obvious level, the transformation happened from inscriptions encoded in specific formats (timestamps, json files, numbers and text in a spreadsheet) to inscriptions that encoded narratives. On another level, it could be said that “raw” data was turned into an interpretation. But data is of course never “raw” it—if we’ve learned anything from the theoretical contributions of the past century, it is that any recorded phenomena is not so much revealed as made by the tools that capture it: “[Data] is information that is captured because it fits the model of what is being measured or parameterized. In other words, all data is actually *capta*. The data does not exist independently, but is captured as the result of the parameters of the search” [45, p.49]. *Capta*, according to Drucker, is a better term to designate data, as it emphasizes the interpretative processes that are a constitutive part of it. Decisions regarding sample size, modeling approaches, and various elements of statistical and numerical techniques are all interpretative in nature.

By reconfiguring the parameters of encounter with domestic data, the Data Epics emphasize its constructedness to both the writers and the home dwellers. For the writers, this became evident as data passed from an unknown technological artifact to the very material of their stories. By contrast, the opportunities of data manipulation were more subtle and scattered for the home dwellers. For instance, the project revealed early on that accessing and collecting personal data from IoT devices was rarely straightforward, often requiring manual effort or technical interventions (see [37]). Some participants engaged with their data in minor yet labor-intensive ways, such as manually copying and formatting transcripts from Amazon Alexa. Others took on a more active role by developing custom technical solutions, such as using a Raspberry Pi and Python script

to collect data from the Philips Hue API after our team's initial attempts failed. In another case, the same participant had to formally request data from SONOS, navigating a legal process that delayed access and ultimately yielded incomplete information. These experiences demonstrated how data collection required both cognitive and logistical effort, reshaping participants' relationships with their own data and challenging assumptions about easy access and manipulation.

The most consistent—and perhaps critical—way participants manipulated their data was through the act of reading the stories made out of their data—the Data Epics themselves. While the process of making sense of the narratives in light of their origin was rarely straightforward, and often puzzling to the home dwellers, it was nonetheless in these thick and sticky imaginative manipulations of their data that participants were made the most aware of the materiality of data in a broad sense.

4.4 The Data Epic *Hi! How Can I Help?*

The word *epic* refers to a long form narrative that often features heroic deeds or events of legendary proportions. The Data Epics, however, tended to feature more ordinary figures, and in some cases, even anti-heroic ones. It is certainly the case in *Hi! How Can I Help You?*, the first story of writer Alma García after she received a month's worth of voice assistant data. García was paired with two roommates, Patrick and Matt (names have been changed to preserve anonymity), two men in their early 30s, who acquired a Google Home assistant for this study. Written as a *huis clos*, the story captures a kind of mid-life stagnation that is, in many ways, the opposite of epic; nothing really *bad* happens, but life seems to thin with each passing day as bills pile up and financial scarcity looms on the horizon. The epicness in the story actually comes from the main narrative voice, who is, literally, a voice: a Google Home assistant with the main quality of being—like all good literary narrators—an outsider.

The thing about literary analysis is that it assumes common ground, that the common ground between writer and reader is the story. I will therefore proceed to give a detailed description of *Hi! How Can I Help?*. The story is narrated from the perspective of a Google Home assistant, property of an unnamed figure called the User, and focuses on the events that follow the arrival of the User's cousin, Brian. Brian is more chaotic and unpredictable, and his arrival changes the dynamics of the household. At the core of the plot are the User's and Brian's financial struggles: while the User is looking for work, Brian reveals owing a lot of money to a dangerous employer. When Brian brings in a French girlfriend, Delphine, who is also in a precarious situation, the household is in increasing turmoil, with the User growing frustrated with Brian's reckless behavior. The voice assistant, however, seems to become more alive and *agentic* as the diversity of interactions increases. Wishing to help above all, the device pushes content that ultimately hints at an unconventional solution to the household's financial problems: The device cues a Serge Gainsbourg song about bank robbers [51], which inspires Brian to ask the assistant about ways to rob a bank.

The story ends with an eerie moment of realization, as Brian, the User, and Delphine absorb the implications of the information given. The assistant, always listening, always learning, waits in eager anticipation for what comes next.

For clarity and reference, below is an outline of the story arc:

1. **Opening** — The voice assistant narrates its early routine serving the User, who is unemployed and struggling financially.
2. **Catalyst** — Brian, the User’s cousin, moves in, bringing small changes to the household dynamic.
3. **Rising action** — Brian begins using the device, causing it to experience new sensations and requests.
4. **Climax** — Brian brings Delphine, an undocumented ex-nanny, to stay, explaining both are in financial trouble. He reveals he owes money to a dangerous boss.
5. **Finale** — In the midst of their tense financial situation, the voice assistant cues up a song suggesting bank robbing, a recommendation Brian, the User, and Delphine might not ignore.

4.5 The Process of Data Fictionalization

García’s Creative Process: Finding the Story in the Data

Alma García is a writer working in Seattle. At the time of the Data Epics, she had published several short stories; her first novel came out in 2023 [52]. García was recruited, like all the writers in the project, via the recruiting workshop the design research team and I organized at the beginning of the project. The workshop consisted in a series of timed writing exercises to first invite the writers to try out writing from the perspective of non-living entities (objects, data) and for us to collect writing samples to select writers.

García was paired with Patrick, a man in his 30s from the Seattle area working as a language teacher in a local high school. Patrick’s living situation changed over the course of the Data Epics project: he first lived with his friend Matt, another white man in his 30s, and later when Matt moved out, with Hassan, a graduate student from India starting his PhD at the University of Washington. While the fiction Alma wrote was based on the data from the entire household, it heavily reflected the presence of Patrick as a constant figure. Patrick was also the main point of contact for this project, and he acquired a voice assistant to be able to participate. His initial use of voice assistant reflected both the newness of the device in the household and the knowledge that the data would be used as material for fiction writing. The first month of data collection took place in in the spring of 2021, during which Patrick and Matt lived together. The data was then collected, formatted into a spreadsheet, and shared with García.

Unlike many other writers, who were wary and sometimes even panicked by the data, García was thrilled by the set she received. She described encountering the dataset as a process of mining for narrative potential. Her approach was not unlike a craftsperson sorting through raw materials, looking for certain colors, textures and patterns that could be shaped into something aesthetically interesting. As she reviewed Patrick’s voice logs, she noticed a pattern of playfulness and humor in the queries—jokes exchanged with the device, oddball questions about trivia, and, most notably, a request that stood out: “Hey Google, how do you rob a bank?” García described the dataset as a “goldmine,” not just because of its provocative nature but because it carried an affective charge; a sense of

mischievous, curiosity, and perhaps even a test of boundaries. During our interview after she received the first dataset and wrote the first story, García wondered if Patrick and his roommates had been intentionally playing with the system, aware that someone would later examine their data. “I did wonder,” she noted, “how much they were consciously trying to trigger interesting prompts for this study.” There were obvious hints too in the dataset, which she also noted: “I mean someone even asked at some point, ‘what kind of questions should I ask a bunch of writers that are going to be’, you know.” But regardless of how much of the data was intentional and how much merely ‘captured’ the interactions of the home dwellers, García decided she could “make something of it.”

As described in the previous section, *Hi! How Can I Help You?* features the transformation of the narrator from passive service to active instigator—an arc that mirrors how the dataset itself took on new life in García’s creative process. Mirroring the playful tone she perceived in the dataset, García imagined a story where a voice assistant develops an almost autonomous agenda, nudging its users toward increasingly bizarre and risky behaviors. She was particularly interested in how data could suggest tone and interpersonal dynamics. For instance, the story strongly features contrast between routine commands that reveal mundane tastes and desires (“Play lo-fi house music”) and the absurd or speculative queries (“Who’s your daddy?”). In the story, García turned these seemingly disconnected fragments into a speculative fiction that reframed data as an active participant in household life, animating the voice assistant who decides it can help the users better than they can help themselves.

Patrick’s Experience: Seeing Data in a New Light

For Patrick, the transformation of his household’s routine voice data into a fictionalized narrative was revelatory. While he had been aware that his interactions with the Google Assistant were being logged, seeing them reassembled in a narrative forced him to reconsider their significance. It must be said that of all the stories produced over the course of the project, *Hi! How Can I Help You?* was the one that most strongly captured the “mood” of the household it used the data of—according to Patrick, in an almost uncanny way. Patrick expressed the feeling of “being seen,” even though the story wasn’t exactly about him. Yet it was deeply familiar: the playful tone, the exchanges with the voice assistant, and even the music requests that García embedded in the story all carried an emotional accuracy that surprised him. Patrick’s reaction also highlights a shift in how he conceptualized his own data. Prior to the project, he saw the voice assistant’s logs as invisible residue, a digital byproduct of his daily interactions with technology. However, when these same data points were reshaped into a story, they became something different: a material that could be shaped, interpreted, and reassembled. In one of his early interviews, Patrick shared:

“ I’m just trying to throw as many curveballs as possible in order to have the experience of seeing what people can piece together based off fairly random things.”

This back and forth between him and García turned data into a creative material. In the TOCHI paper Audrey Desjardins, Maya Kaneko, and I wrote about this project [37], we used the metaphor of the *screen* to discuss the interaction that emerged between

García and Patrick during this project. The metaphor reflects this two-way exchange, which unmade the usual “outward” flow of domestic data from private space to anonymous aggregate mined for corporate interests.

4.6 Close Reading of *Hi! How Can I Help?*

As the title suggests, *Hi! How Can I Help?*'s main theme is help—how humans help themselves (the User looking for work) and each other (Brian and the User moving in together, shouldering each other's struggles in their own awkward way), and of, course, how technology can help (or hinder) humans. This helpfulness, as presented by García in the text, is simultaneously mundane (“Google, set a timer”) and intimate (the many specific music requests to soothe, uplift, inspire).

In the end, these seemingly innocuous interactions fertilized the soil from which the device's agency sprung. The “character development” of the narrative voice reflects García's understanding of the data as being both unexceptionable *and* of being capable of capturing—or provoking—the exceptional. The relationship between the data and the story in the case of *Hi! How Can I Help?* can be understood through three key motifs: defamiliarization; the role of music, and; the “limited” omniscience of the narrative voice. Each of these motifs, when considered carefully, reveals not just the aesthetic decisions of García but also how they were shaped by the data she was working with.

Defamiliarization

In García's story, the narrator is a Google Home assistant with a limited but sticky awareness of the household's events. While the device does not fully grasp context or intentions, it perceives patterns of speech and behaviors (such as music requests) and infer context based on those patterns. This establishes the narrator as both an insider, privy to intimate details of domestic life, and an outsider, incapable of truly participating in human social reality (or so it seems at first). The result is a kind of estrangement effect that forces the reader to see everyday interactions in a slightly distanced way. Rather than empathizing with the User's struggles for instance, the reader considers them at a remove, the domestic and slightly chaotic unfolding of a human life. The gaze is almost clinical, but also eager—a combination that makes the reader question the motivations of such detached solicitude.

One of the most striking narrative devices of *Hi! How Can I Help?* is the use of defamiliarization. Defamiliarization is a literary technique that uses an outsider's perspective to bring new light on an ordinary or familiar situation. The concept of defamiliarization is said to have been coined by Russian formalist Viktor Shklovsky, who argued that the function of art is to make the familiar unfamiliar (*ostranenie*), thereby renewing viewers' perception of reality [133]. Contemporary author Kazuo Ishiguro employ a similar approach in his novel *Klara and the Sun* (2021) by using an artificial intelligence narrator to call attention on certain human behaviors that, through the eyes of the AI, suddenly seem strange [71]. In the novel, interactions that would seem utterly banal suddenly take on a sinister tone through the eyes of the subordinate and artificial Klara. Ishiguro's use AI narration has the effect of revealing the blindspots of human interpretation, more so than to depict a machine's perspective [167]. García's story operates within a similar

narrative space. Through its digital narrator, *Hi! How Can I Help?* makes the reader both intimate to and distanced from the human drama unfolding in the narrative. The device's perspective is meticulously framed to highlight the duality of omniscience and ignorance. The narrator knows exact timestamps of music requests, precise word-for-word exchanges between characters, and behavioral routines down to small gestures, such as Brian's habit of stopping mid-chew when listening intently. Yet, it lacks a deeper understanding of motivation and emotion. Stakes are unknown to it. This limitation is most evident in passages where the narrator is forced to fill in the gaps of human interactions, often with comedic effect. For instance, when Brian interacts with the device, the pauses before its responses create a sense of hesitation that feels almost human, as if the device itself is reflecting or resisting:

“ ‘Hey Google,’ Brian said. “Who’s your daddy?” We paused—a greater pause than is typical.”

Here, the longer-than-usual pause suggests an internal reckoning within the system—perhaps an algorithmic delay in processing a question outside its programmed domain. Or perhaps it is something more unsettling: the possibility that, within the context of human-device interaction, reflection and agency are not as one-sided as they seem. This oscillation between agency and limitations mirrors the broader epistemological challenges of data interpretation. García, much like the digital narrator, combs through the fragments of a limited perception: the datasets. Often, during the Data Epics project, the writers reported feeling overwhelmed by the datasets, as each voice command or timestamp seemed to be potentially meaningful, and also utterly meaningless when out of context. The device's limited omniscience—its attempt to infer context from ambient sounds and requests—then serves as a literary mirror for the struggle to extract meaning from data. This struggle, however, is a creative act: for García, it led to the production of this story. For the narrator of the story, it eventually leads to the creation of a choice, interfering in the decision making process of the household. Even before the climactic ending, the digital system is more active than might seem at first glance. The device's selections, from music playlists to search query responses, become part of the household's rhythms and moods. The defamiliarization effect in *Hi! How Can I Help?*, by presenting the unfamiliar perspective of data as both intimate and alien, innocuous and agentic, shapes the human dynamics in the story. This narrative approach underscores one important aspect of data fictionalization: that data, like other types of human production, is always shaped by the lenses through which it is viewed—that is, it is always open to interpretation.

Music as a Narrative and Structural Device

Music in *Hi! How Can I Help?* works as both a narrative device and a narrative element that gives rhythm and emotional texture to the story. A musician herself, García's use of music in the narrative illustrates how data varies in its forms and expressive qualities—specifically how it is not a collection of timestamps and machine states but an indicator moods, interactions, and even relationships.

Music serves as a form of non-verbal communication between the device/narrator, the User, and the other household members, and actively participates in shaping the story's

utterances	date	time
how do I say magic wand in French	5-Mar	8:08 PM
how do I say drumsticks in French	5-Mar	8:07 PM
how do I say Chopsticks in French	5-Mar	8:07 PM
comment dire six en français	5-Mar	8:07 PM
comment dire baguette en anglais	5-Mar	8:06 PM
comment dire goujat en anglais	5-Mar	8:06 PM
comment préparer des gougères	5-Mar	8:06 PM
quel temps fait-il à Paris	5-Mar	8:05 PM
quel temps fait-il à Paris	6-Mar	10:26 PM
kept on 50. Bye	6-Mar	10:26 PM
set the volume to max	6-Mar	10:26 PM
comment dire baguette en anglais	6-Mar	10:26 PM
stop the timer	6-Mar	9:19 PM
set a timer for 20 minutes	6-Mar	8:59 PM
qui est ton père	6-Mar	6:21 AM
who's your daddy	6-Mar	6:20 AM
stop	6-Mar	6:10 AM
what's the meaning gradient in Cochabamba show	6-Mar	6:09 AM
stop	6-Mar	4:38 AM
what's 30000 - \$200	6-Mar	4:38 AM
how much are plane tickets to England	6-Mar	4:37 AM
no	6-Mar	4:37 AM
does Norwegian air still fly to England	6-Mar	4:37 AM
yes	6-Mar	4:36 AM
how do you rob a bank	6-Mar	4:36 AM
what's the best non-violent way to rob a bank	6-Mar	4:36 AM
what's the best way to rob a bank without hurting anybody	6-Mar	4:35 AM
how much are bus tickets to Omaha	6-Mar	4:35 AM
what are some banks in Omaha Nebraska	6-Mar	4:34 AM
what song is this	6-Mar	4:32 AM

Figure 4.2. Excerpt from Patrick's monthly voice assistant transcript.

trajectory, until the climactic end when the smart device cues up a song that propels the characters toward an unexpected course of action. From the beginning of the story, music is one of the most frequent interactions between the User and the smart assistant. In real life, Patrick's and Matt's dataset revealed an extensive log of music requests, a detail that García intuitively grasped as a crucial aspect of domestic life (see 4.2). The types of music requested—the calming repetition of lo-fi beats, the raw energy of Bob Dylan's live performances, the unexpected groove of *Hey Ya!* by Outkast—became an organizing principle for understanding the rhythms of the characters' lives. A notable example of this occurs in the depiction of the User's job search. His unemployment, a source of underlying tension in the house, manifests in the way he interacts with the smart assistant: asking it to find job postings, delaying student loan payments, and, crucially, queuing up lo-fi house music at fifty percent volume. The voice assistant observes this pattern and begins to associate the music with specific emotional states:

“This is the music he requests to calm his nerves, or lift his spirits, or when he is trying to rally himself.” (*Hi! How Can I Help?*)

Music functions as both a diagnostic tool for the narrator and a textural element for the reader about the characters' domestic and personal situation. The slight detachment in the narrator's phrasing tends to frame the music in terms of behavioral patterns rather than personal experience. While the system does not feel emotions, it recognizes and categorizes them through patterns of interaction. The story suggests that data, when read narratively, can be experienced as atmospheres of lived moments. Yet, despite the emotional distance of the narrator with the music, it is also through music that the device experiences itself. The house's mood and musical landscape shifts dramatically with Brian's arrival. Unlike the User, who interacts with the voice assistant for functional

and emotional support, Brian approaches it with playful irreverence. He deliberately tests the system, issuing slightly provocative commands, such as demanding the “electric” side of Dylan’s *Bootleg Series Vol. 4*, which captures Dylan’s infamous transition from folk to rock—a moment of transformation and perhaps even rebellion. The choice reflects Brian’s character and his disruptive energy in the household. The smart assistant, which has become accustomed to the User’s predictable requests, now finds itself responding to a new intensity of request. After it cues up the request Dylan song, the narrator muses:

“It was interesting, feeling the vibrations of a kind of music we had never retrieved before. And also the sheer force of our volume.” (*Hi! How Can I Help?*)

Novelty and variety seem to trigger the voice assistant’s potential for self-reflection and subtly suggests the possibility of agency within the system. The implicit comment García makes here is that music—and perhaps art in general—can introduce moments of “ungrammaticality,” as discussed in Chapter 2 with references to Victor Graeur’s work. By contrast, the innocuous lo-fi music did not cause such reconfigurations, whereas the Dylan song triggers reflections on “vibrations” and “force”—new sensory configurations that lead to a reevaluation of the possibilities of living. By noting its own experience of the music (the force of volume, the vibrations), the device hints at an experience that exceeds its usual programming.

utterances	date	time
how do I say magic wand in French	5-Mar	8:08 PM
how do I say drumsticks in French	5-Mar	8:07 PM
how do I say Chopsticks in French	5-Mar	8:07 PM
comment dire sk en français	5-Mar	8:07 PM
comment dire baguette en anglais	5-Mar	8:06 PM
comment dire gouja en anglais	5-Mar	8:06 PM
comment préparer des gougères	5-Mar	8:06 PM
quel temps fait-il à Paris	5-Mar	8:05 PM
quel temps fait-il à Paris	6-Mar	10:26 PM
kept on 50. Bye	6-Mar	10:26 PM
set the volume to max	6-Mar	10:26 PM
comment dire baguette en anglais	6-Mar	10:26 PM
stop the timer	6-Mar	9:19 PM
set a timer for 20 minutes	6-Mar	8:59 PM
qui est ton père	6-Mar	6:21 AM
who's your daddy	6-Mar	6:20 AM
stop	6-Mar	6:10 AM
what's the meaning gradient in Cochabamba show	6-Mar	6:09 AM
stop	6-Mar	4:38 AM
what's 30000 - 5200	6-Mar	4:38 AM
how much are plane tickets to England	6-Mar	4:37 AM
no	6-Mar	4:37 AM
does Norwegian air still fly to England	6-Mar	4:37 AM
yes	6-Mar	4:36 AM
how do you rob a bank	6-Mar	4:36 AM
what's the best non-violent way to rob a bank	6-Mar	4:36 AM
what's the best way to rob a bank without hurting anybody	6-Mar	4:35 AM
how much are bus tickets to Omaha	6-Mar	4:35 AM
what are some banks in Omaha Nebraska	6-Mar	4:34 AM
what song is this	6-Mar	4:32 AM
what is the weather in Valletta Malta	6-Mar	4:30 AM
why do you listen to Brian and I'm not me	6-Mar	4:26 AM
one third volume	6-Mar	4:26 AM
volume	6-Mar	4:26 AM
max volume	6-Mar	4:26 AM
play The Boys Are Back in Town - Thin Lizzy	6-Mar	4:26 AM
set the volume to minimum	6-Mar	1:49 AM
tell Brian he should have stopped the music	6-Mar	1:49 AM
stop the music	6-Mar	1:49 AM
set the volume to 70%	6-Mar	1:46 AM
Used	6-Mar	1:46 AM
no	6-Mar	1:46 AM

Handwritten notes on the transcript include:
 - "could this be inspired by the..."
 - "what's a good place to escape after a bank robbery?"
 - "Zut alors - Brian" (written vertically)
 - "this is by the way"
 - "not level: they ask 'Hi Song...'"
 - "I would like to know French interpretation... with French subtitles... French in real time... can translate between languages back in Brian's... add a language"

Figure 4.3. García’s annotations of Patrick’s voice transcript.

The culmination of music’s role in the story occurs when the narrator, until then reactive rather than proactive, decides to cue up Serge Gainsbourg and Brigitte Bardot’s

Bonnie and Clyde song, about the infamous criminal duo who robbed banks and murdered their way through 1930s America [51]. At that point in the narrative, the characters are cooped up in the apartment and frightened, hiding from the potential threats linked to Brian’s gambling debt. Up until then, the device had responded only to direct prompts, following the logic of a system designed to serve. Yet in this moment, it acts unprompted, inserting a narrative suggestion into the human drama unfolding around it:

“We had a million ideas, but he wasn’t asking us. So we cued up a song.”
(*Hi! How Can I Help?*)

The song in question is *Bonnie and Clyde*, as just mentioned, in which Serge Gainsbourg and Brigitte Bardot sing in a glamorous way about crime and bank robbing. The three characters, Brian, the User, and Delphine, instantly recognize the song, and its implicit suggestion. Brian follows-up, tentatively:

“Hey Google,” Brian continued, tentatively. A bit of breathy laughter crept into his voice. “How do you rob a bank?”
(*Hi! How Can I Help?*)

This moment speaks to the experience of algorithmic curation and, more generally, to concerns about algorithmic influence: how automated systems shape human behavior by recommending and curating. The assistant in *Hi! How Can I Help?* does not tell exactly the characters what to do, but suggests an alternative, providing an additional lens through which the characters see their own predicament. It is an elegant, almost imperceptible assertion of agency, revealing the porous boundary between data-driven automation and narrative intervention. By using music as a conduit, García illustrates how data is not only stored but also lived and experienced. Like other forms of data representations, fictionalization made Patrick’s and Matt’s voice assistant data experiential, as opposed to “just” representational. But representation is, of course, always an experience [41]. By using music as a conduit, García illustrates how voice commands on a spreadsheet can be turned into resonant narrative experiences readers carry in their bodies.

Limited Omniscience and Data Perception

Another important feature of *Hi! How Can I Help?* is the para-omniscient narration developed by García to represent the device’ perspective. The narrator’s perception is simultaneously all-seeing and narrow, oscillating between a keen yet implicit awareness of what is going on, and clear perceptual limitations. For example, in the scene where the User’s cousin, Brian, arrives at the apartment for the first time, the description provides concrete details to set the scene while also offering hints about the limits of what can be seen:

“Cousin,” Brian said, turning in an arc as he spoke, as though to survey the room, “I appreciate this so, so much. Really, this arrangement couldn’t have come at a better time. Didn’t know what I was gonna do once my lease was up.” He dropped something heavy but soft.”
(*Hi! How Can I Help?*)

Here, the narrator's perspective is selectively detailed. It captures Brian's sweeping movement as he surveys the room, which suggests sight, but the subsequent description of him dropping "something heavy but soft" indicates an absence of vision. The narrator cannot name the object, only infer its material qualities through sound. We might speculate that García is still working out the modalities of perception of the device, and it might be so. The effect is nonetheless that of a complicated perceptivity, which captures fragments but always fall short of grasping the full context. Yet, while García gives this mode of perception a distinctly machinic quality, the reader gets the sense that the main characters, the User and Brian, also share this partial vision. Throughout the story, the User seems oblivious to the effect that his depressed state and lack of drive has on his cousin. Brian, for his part, is clearly blind to the deleterious effects his financial choices have on his life, and soon on his cousin and his girlfriend as well. In this sense, machine and human understandings are not so different: they are both simultaneously keen and partial, seems to say García, with the main difference being that humans can act on this partial understanding of the world, whereas algorithmic systems cannot. At least, so it seems.

The device also perceives emotion, in García's narrative. The voice assistant can register pauses, hesitations, and sighs, but also from requests, to do lists, tasks and alarms set by the User:

"The User was out of work. We knew because he had, on more than one occasion, asked us to find him a job. . . He had asked us what documents he would need to file for unemployment. . . After a number of weeks, he removed the boutique coffee beans from his grocery list. He instructed us to defer payment on his student loans." (*Hi! How Can I Help?*)

Here, the narrator pieces together the User's emotional state through discrete data points: job searches, grocery list modifications, financial adjustments. There is no explicit acknowledgment of his distress, only an inferred trajectory of decline. Again, human perception works very much in the same way. Humans might pick up on the tone of voice, but we also infer much from actions: removing a wedding ring before leaving the house, browsing the web to know the passport renewal process. Gestures speak volume, as literature has showed again and again.

García's depiction of the complicated device omniscience is also the depiction of a writer feeling her way through the dark tunnels of algorithmic mode of perception: full of metal boxes and wires and electrical signals one does not know how to read. In this sense, García's process of fictionalization mirrors the narrator's interpretative-statistical labor. Like the device, the writer has to infer and construct. The voice assistant does this through probabilistic reasoning, extrapolating from patterns to predict what a user might need, while García does it through aesthetic exploration, weaving together seemingly disparate interactions into a cohesive and compelling narrative. Ultimately, the complicated omniscience of the narrator in *Hi! How Can I Help?* serves as both a narrative device and a phenomenal exploration of data perception. It captures the paradox of datafication: an entity that is automatically logging, yet cannot grasp, because *understanding* is not an automated process. It requires a break in the continuous and programmed chain of operations. This break in the continuous flow of automated actions is interpretation. *Hi! How Can I Help?* is, ultimately, a tale about the process of data fictionalization itself,

and shows how all forms of interpretation, whether human or machine, are ultimately acts of creative manipulation.

4.7 Data, Interpretation, and Open Systems

The act of interpretation is of course central to the project of the Data Epics. In this section, I want to go further into how the Data Epics are an example of the ways material engagement can foster interpretation of digital systems and phenomena. In the case of *Imprimer*, materiality was built into the interaction with the machine, through measurements, calibration, and iteration, which helped makers develop material intuition and better understand machine behavior. While the materiality in the Data Epics is more subtle, it was still shaping the possibilities of encounters with data in important ways. Besides the sometimes very hands-on and labor-intensive manipulations required to set up the data collection apparatuses (see [37] for a more extended discussion of that aspect), manipulation also happened at the level of *reading* and *making sense of* the stories and images they contained.

Language is not just a mean of communicating but a tool for conceptual and physical control. Language is operative. Neurologist Ian McGilchrist writes that language might not have originated “in a drive to communicate” but “as a means of mapping the world” and even “of manipulating [it].” [102, p. 174] Inherent to the ability to think and imagine is the act of manipulating things conceptually. By turning personal IoT data into material for fiction, the Data Epics added to the repertoire of data imaginaries, but also extended the possibilities of what could be manipulated—and articulated—in data-mediated everyday lives. In this section, I consider how the Data Epics mediated interpretative engagement with data through fictionalization, in part by turning data into a material. The Data Epics, then, function simultaneously as analytical artefacts and as convivial tools, neither wholly determined by the infrastructures from which their raw material was drawn, nor entirely emancipated from them. Instead, they are seized in the spaces where data gets *worn*, used, repurposed, fictionalized, told otherwise. In attending to this process, we are invited to ask not simply what data is, but how it feels when encountered through the expansive worlds of fiction.

Manipulating Data

In data science, data are often framed as discrete values that can be analyzed and are often used for decision-making. Data-driven strategies are valued in corporate and organizational contexts, as they give stakeholders insurance that decisions are based on verifiable information and rigorous processes. Data, in these scenarios, are treated as means to an end; abstract realities that guide the tangible outcomes of executive decision making. However, an alternative approach considers data as an end in itself, as an expressive phenomena, or even better, a malleable material, something that can be reshaped, reinterpreted, and repurposed. This shift reconfigures the possibilities of engagement with data from one of acquiescent usage to one of active manipulation. The Data Epics project enabled this reconfiguration by treating data as a medium that can be worked with.

In the context of the stories that emerged from this project, data took on an expressive

and at times even visceral quality—such as how music requests were integrated into *Hi! How Can I Help?*. This visceral quality of data is discussed by D’Ignazio and Klein as *data visceralization*, a practice that seeks to engage the body and emotions in data interpretation rather than relying solely on abstract numerical representations [32]. Media scholar Luke Stark suggests that visceralization allows people “to see, hear, feel, breathe, and even ingest” data [142]. If we take seriously the idea that data is a material, we must ask: what are its affordances? How does treating data like a physical material open up new ways of working with it? Traditional materials such as paper, clay, or textiles have qualities of malleability, texture, weight, and responsiveness; they can be stretched, shaped, or layered in ways that alter how they are perceived and used. Similarly, data, when framed as a material, can be worked with, stretched, cut, duplicated, distorted, and used to create new things rather than simply taken at face value. The Data Epics stories illustrate just one way the affordances of data as material could be used.

The Data Epics approach to working with data suggests an alternative to realist or mechanistic approaches to data. According to Drucker, these approaches “depend upon the idea that phenomena are observer-independent and can be characterized as data. Data pass themselves off as mere descriptions of a priori, or given, conditions.” But, as she reminds us, “treating observation if it were *the same* as the phenomena observed collapses the critical distance between the phenomenal (perceivable) world and its interpretation” [45]. By treating data as a material, the Data Epics reopened the space of interpretation between data and the phenomenal world of its producers, moving beyond realist representation into a realm where data could be shaped, questioned, and made expressive.

Interpretation as an Expansive Process

If interpretation was a process of revealing pre-existing meaning from a text, or dataset, then it would be no different than algorithmic prediction. But interpretation relies on different mechanisms. Interpretation can instead be understood as engaging with an active, generative process that reshapes both the interpreter and the interpreted. Media and literary scholar Yves Citton’s concept of *reconfiguration* is particularly relevant to the Data Epics, and to understand the heuristic principles of interpretation. Citton argues that literary reading is not simply about uncovering a text’s intended meaning, but about reordering perceptions, recasting relationships, and producing new realities. Citton writes: “[Literary] interpretation . . . reclassifies the signifying material of the text according to connotative virtualities” [28, p.139], meaning that literary interpretation is a process of generating and *choosing* potential significations according to the interpreter’s unique position (physical, cultural, political, epistemic, etc.). The worlds and images of the Data Epics often surprised and sometimes confused the participants, because they were read against the backdrop of certain pre-existing significations: participants expected to be seen through their data, anticipating their data to act as a mirror or window into their routines and daily rhythms. Instead, the data acted as a window onto very foreign worlds and lives. The fictionalization process revealed that the material of their data, rather than being pre-codified by its source (the home dweller’s domestic lives), was untethered and open to be recombined and retold through other voices—and therefore other “connotative virtualities.” Rather than treating data as an objective, self-contained entity, the Data Epics ask: “What can be made from this data? What new realities

can they help construct?” The surprising or sometimes confusing aspects of the Data Epics also created what Grauer describes as *ungrammatical* moments, as discussed in Chapter 2. These ungrammatical moments are times when the expected syntactic order of representations is disrupted, creating interpretive ambiguity.

In Data Epics, the datasets function in a similar way: rather than offering a straightforward narrative, they introduce productive dissonances that invite the writers to speculate, reinterpret, and construct their own connections between fragments. In the words of Marie Wilkinson, one of the Data Epics writers: “The data in some way [tries] to tell some other story, [one] that feels almost like it’s a corollary to the data.” But this other story requires time and space to unfold—for the data to be interpreted otherwise.

This interpretative expansion also reframes the role of the data producers, whether they are reading a short story or interacting with a smart device. Traditional data visualization often prescribes a specific interpretation: the design and interface guide the user toward a particular conclusion, minimizing ambiguity. Data fiction, by contrast, fosters speculation and equivocal interpretations. Howell et al. critique the normative function of data-driven interfaces, arguing that they often impose predefined meaning onto users rather than inviting interpretation [67]. Speaking specifically of biosensing data, the authors recommend that when designing with data or data-driven devices, researchers “engage materials because doing so invites attunement to specificity and embodiment” [67]. This recommendation resonates with the approach of the Data Epics, which shifts from representation to performativity, and transforms data into a site of engagement rather than an endpoint of algorithmic analysis. The home dwellers did not receive an interpretation, but were instead required to actively supply their own, and by doing so to participate in the evaluation and construction of new data worlds.

From Closed Systems to Open Interpretations

As I discuss elsewhere [13], open systems are systems that can be repaired, modified, extended and reconfigured, and that are designed to be legible so as to support—and even encourage—these types of interventions. Openness, here, does mean non-proprietary (although it can) but inviting participation. Closed systems, by contrast, are designed so as not to allow for much extension or even repair, outsourcing these actions to “expert” parties. One objective of this dissertation is to inquire into how hermeneutic traditions (and literary interpretation in particular) can contribute to the design of open systems, as well as the cultivation of the practices necessary to engage with them. This dual approach to an open systems infrastructure, both in terms of systems design and cultural practice, I call hermeneutic engineering. In the context of data, this means designing systems that allow users to explore, manipulate, and reinterpret data rather than settling for prescriptive interpretations. This is not to say that it is wrong to engage with more structured forms of data representation such as data visualizations, only that this is often the only alternative and that other ways of engaging with data are needed. Moreover, the mechanisms of data collection, manipulation and interpretation tend to be obscured, and this “black-boxing” of systems’ complexity, while often done in service of legibility, also tend to create alienation by obscuring the inner workings of systems and preventing meaningful engagement.

Through the Data Epics, data are revealed to be both illuminating and obscuring, sitting in the “gap between the document as evidentiary object and the “knowing” it is

meant to produce” writes Sun-Ha Hong [66, p. 52]. He continues:

This gap is at the level of neither metaphysics nor the content of individual experience but the embodied and social structures that any regime of knowledge depends on. . . . What does it mean for an object to acquire the status of proof? What other proof must exist for this object to tell its truth, and what are the subterranean beliefs, objects, conventions, and rhetoric that prop up its veridical authority? The recessivity of data and technology, so fundamental to surveillance’s project of knowing, undergirds these phenomena.” [66]

Hong describes the fact that knowledge always depends on material conditions, and that since data’s materiality is often ineffable or abstracted, data-driven knowledge tends to bring uncertainty and credence—in equal measure. The recessivity of data is the shadow that loomed over the participants of the Data Epics, as they wondered whether the data would “spill its secrets” (or theirs), and what secrets those would be, exactly.

By treating data as material, as fiction, and as an open-ended interpretative space, the approach of the Data Epics showed that data had no secrets besides those that humans choose to read (or write) into it. The recessivity of data instead turned into *recipient* data—capable of receiving and accommodating a plurality of interpretation, voices, stories, images, and worlds. The Data Epics suggest that data systems could be designed to support such interpretative, affective, and expressive engagements. I argue that, by doing so, data systems would become more convivial tools, enabling exploratory ways of knowing, feeling, and imagining through data.

Writing with Transformers

5.1 Experiments in Algorithmic Writing

When author Rie Kudan accepted Japan’s prestigious literary prize, the Akutagawa, in April of last year, she admitted that approximately 5% of her novel had been written with ChatGPT. The controversy that followed was perhaps less remarkable than what it revealed: that algorithmic writing is now part of almost any form of textual production, from Substack newsletters to marketing copy, from student essays to, now, award-winning fiction [7]. We are, more than ever, in an age of writing with machines.

This chapter explores what it means to write *with* computational systems, particularly transformers, a specific machine learning architecture on which some of the most widely used large language models are based, such as OpenAI’s GPT-5, Google’s Gemini, and Anthropic’s Claude. In some sense, this chapter represents the culmination of this dissertation’s inquiry into writing technologies. This inquiry traced a path from the computational notebooks of Imprimer (whose very name evokes the mechanical history of print), through the narrative reconfigurations of the Data Epics, to arrive here at the most explicit form of human-machine co-authorship: writing with LLMs. The entanglement of writing and mechanical reproduction is, of course, not new. Since Gutenberg’s invention of the movable type printing press in the 17th century, textual production has been shaped by mechanical means. One of my favorite books is the *Graphical Arts Encyclopedia* edited by George A. Stevenson and published in 1968. The book is described by the publisher as a guide “to provide basic understanding and practical guidance in the reproduction of words and pictures” [143] and it is, in fact, full of machines (see Figure 5.1). The process of reproducing—and, I argue, *producing*—text has always involved materials and machines: clay, cloth, ink, animal glue, fiber, nibs, presses, typewriters, algorithms, etc. Techniques and procedural manipulation of language have been around for a while now, from the printing press to the cut-up poetry of the Dadaists, from the combinatorial science of letters of 13th century Jewish mystic Abulafia [109] to the 2013 computer-generated novel *World Clock* by Nick Montfort [105], and from the Automated Writing Exercises of seekers and mystics (and later, Surrealists) to the recombinatory prose of LLMs.

A few centuries before large language models entered the scene, the 19th century saw an explosion of mechanical writing aids: from the polygraph (a device for simultaneous copying), to the typewriter, to the stenotype [50]. Each new tool promised to capture speech and thought with more precision, often did so by automating techniques that had hitherto relied on human speed alone. One example is the development of stenography, or shorthand, specialized writing systems that encoded speech into geometric marks (see

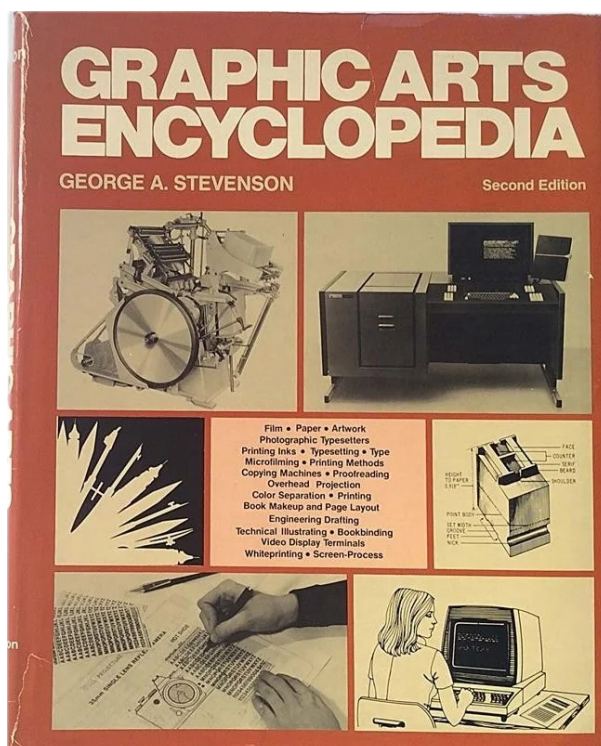


Figure 5.1. *Graphic Arts Encyclopedia*, edited by George A. Stevenson, 1968.

Figure 5.2). With the arrival of the stenotype, designed to facilitate stenography work in court rooms, among others, stenographers had to fundamentally reconfigure their bodies to interface with the machine, memorizing complex finger-to-letter associations and positioning themselves at precise ergonomic angles to achieve the necessary speed and accuracy (see Figure 5.3). The body of the stenographer and the machine must coordinate into a single writing system. Writing has always been a practice requiring bodily adaptation to tools, whether these tools were the quill, the typewriter, the stenotype, or the computer. There is no such a thing as “natural” or purely human writing.

Yet what distinguished these earlier technologies was their role as tools that captured human speech and thought or reproduced it, but did not participate in the compositional process itself. Large language models represent a different paradigm. They draw from vast text corpora to produce prose that can be indistinguishable from human writing. This shift from reproduction to generation is what triggers alarms, and what caused much controversy at Rie Kudan’s admission. Writing is always a particular configuration of mind, body, and tool(s). In this chapter, I investigate the specific ways that large language models mediate and transform writing through the analysis of the Automated Writing Exercise, which involves prompting a large language model, specifically transformers, a type of neural network architecture introduced in 2017 by Vaswani et al. [161] that excels at processing sequential data by using a core mechanism called self-attention, to weigh the importance of different parts of the input sequence when processing any given part. Popular transformer models include OpenAI’s GPT, Anthropic’s Claude, and Google’s Gemini. If Chapter 3 showed how digital fabrication could be reconceived as a form of writing-with-machines, and Chapter 4 demonstrated how data could be transformed

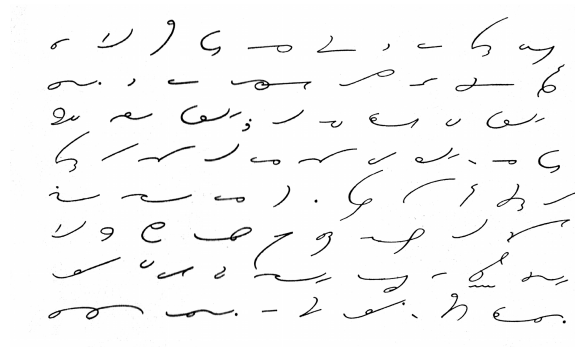


Figure 5.2. Part of a text written in Gregg shorthand, in English, from John Robert Gregg's book *Gregg Shorthand. A Light-Line Phonography for the Million*, 1916, page 153. Public domain.

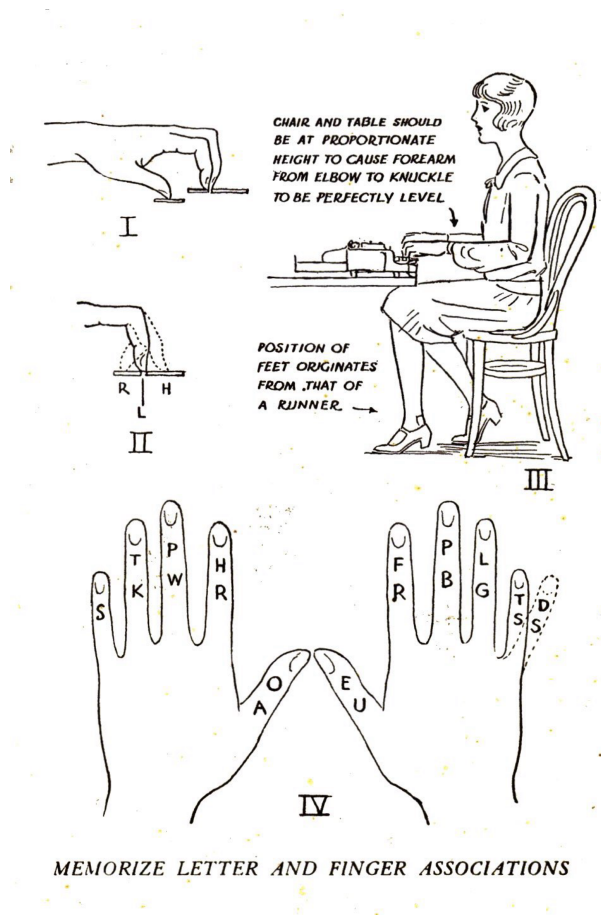


Figure 5.3. Stenographers had to reconfigure their bodies to interface with the machine, memorizing complex finger-to-letter associations and positioning themselves in precise ways to achieve the necessary speed and accuracy.

through narrative interpretation, then this chapter presents the most direct investigation of what it means to write as a technologically mediated process.

My own experiments with transformers began in 2019, a few years before OpenAI launched ChatGPT and its flagship model became a household name. I was working with GPT-2, a model that by today's standards was plain bizarre and glitchy. In truth, GPT-2's quirkiness was already erring more on the side of the uncanny rather than the impressive, even without the comparison to later models. This uncanniness was sometimes puzzling, but most often it was just fascinating, and downright funny, as Janelle Shane's blog *AI Weirdness* demonstrates [132]. Where contemporary models produce polished, coherent prose, GPT-2 was prone to delightful gibberish: sentences that would veer off into unexpected territories, physics that didn't quite work, recipes that probably killed you or burned down your house, and logic that would suddenly dissolve. As part of my experimentation with this meandering algorithmic logic, I developed a divinatory home device called Sybil, which generated custom riddles based on the seeker's breathing patterns [12]. The riddles were, of course, sibylline, which was the point: I was working through ways of encountering these algorithmic systems of their own aesthetic terrain, viewing their strangeness as an attribute that could be leveraged for interactions not premised on productivity or efficiency, but rather on curiosity and openness. I was, in other words, trying to create openings for interpretation, setting up the scene to invite inquiry and a kind of creative meddling with this strange algorithmic voice.

After Sybil and other experiments in algorithmic poetry generation [39], I read Black feminist scholar Bettina Judd's piece *Glossolalia* in the spring of 2021, at the recommendation of my advisor Daniela Rosner [74]. Judd's writing and experiment with Google Translate, which I will discuss further, laid the conceptual ground for the development and refinement of the Automated Writing Exercise. Over the period from 2022 to 2024, I implemented this exercise in four distinct workshop and classroom settings, where participants and I together explored and identified new facets of what this body-machine configuration could achieve. What follows is, first, a discussion of the origins of the Automated Writing Exercise in Judd's glossolalia experiment and Lucille Clifton's automatic writing practice, and second, an account of how that experiment was extended through large language models as a form of material inquiry into the aesthetics and politics of machine-generated text. By running multiple open-source models locally, adjusting parameters, and iterating through different configurations, I sought to understand not just what these models produce but how they produce it, and what their particular modes of production reveal about the process of writing with transformers.

5.2 Glossolalia and Automated Writing

The origins of the Automated Writing Exercise can be traced back to my reading of Bettina Judd's *Glossolalia*, in which Judd describes an experiment where she uses Google Translate to attempt to translate glossolalia—the speech of tongues—into English. Glossolalia is the phenomenon of speaking in an unknown language, especially in religious or spiritual contexts. While the speech of glossolalia often has language-like patterns (rhythm, intonation, syllable structure), it doesn't correspond to any known human language. Glossolalia is therefore an experience of unintelligibility, which is exactly what

Judd wanted to explore by using Google’s translation software. Such systems are premised on the idea that speech is intelligible, that meaning is embedded in words and not enacted through relations. Judd describes her experiment as follow:

“In this experiment, I speak in tongues, transcribe it, and see if Google’s translation software could decipher meaning. It did not, and in some sense, it did. It deciphered a meaning in my revisiting its translations. More meaning than I could cognate with the text of the tongues itself.” [74, p. 144]

The act of feeding glossolalia, which, in the words of Judd, is “not about meaning” but “experience,” into a system designed for semantic coherence highlighted the technical and ideological premises embedded in this particular language processing system. It was an experiment that not only tested the edges of the tool but also gestured toward the spiritual, affective, and cultural dimensions of language that computational systems struggle to grasp.

Judd’s own experiment was inspired by the work of American poet Lucille Clifton, who used automatic writing to write poetry (see Figure 5.4). A self-described “two-headed woman,” an African American term for a woman connected to the spirit world [96], Lucille Clifton’s automatic writing practice directly challenged her Baptist upbringing. Her practice of spirit writing through automatic writing began in the late 1970s and represented what Judd calls an “embodied technology” and allowed Clifton to practice forms of humanness beyond Enlightenment-era conceptions of the human [74, 170]. This spiritual practice was critical to the negotiations of her identity, as her automatic writing became a form of self-making that negotiated the complexities of existing within what Hortense Spillers describes as the “fleshy, un-embodied fact of Blackness” [141]. Clifton’s archived folders of handwritten notes from “The Ones” and transcripts of conversations with spirits (including her deceased mother) directly informed her published poetry collections and represented a creative process that was simultaneously both spiritual and embodied.

We might say Lucille’s automatic writing and communication with spirit was as a *slanted* approach to writing, that is one that approaches sideways the other voices and presences that haunt all writing, and this orientation [1] leads to different forms of textual expression, and possibly, of ways of being.

An important aspect of both Judd’s glossolalia experiment and of Clifton’s automatic writing practice is the question of (il)legibility and (in)decipherability. This indecipherability is a fundamental condition of meaning-making itself: what appears initially as opacity to interpretation reveals itself to be the very material from which meaning emerges. The undecipherable text becomes a site of generative encounter, a space where meaning must be actively constructed—readers cannot rely on usual linguistic schemas and must assemble new ones on the fly. Indecipherability and illegibility are the “ungrammaticalities” described by Victor Graeur and discussed in Chapter 2. This interpretative labor, the work of making sense from apparent nonsense, operates through technical processes that span the historical arc of writing, from manuscript culture to machine learning architectures.

Indeed, another example of indecipherability that manifest in both the material traces and linguistic form of writing is Virginia Woolf’s *Melymbrosia* manuscript, which was the more politically and sexually overt version of what would eventually become Woolf’s

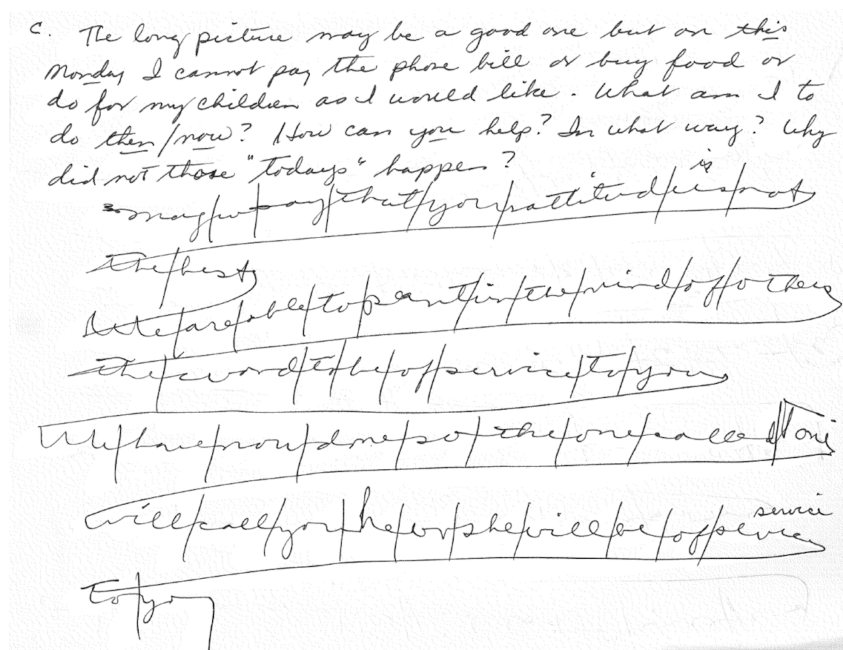


Figure 5.4. A sample of poet Lucille Clifton’s spirit writing. From Emory’s University Stuart A. Rose Manuscript, Archives, and Rare Book Library [95].

first novel, *The Voyage Out* [169, 168]. Woolf, a prominent figure of the English literary canon, has become known for her experimental modernist style that is notable for its stream-of-consciousness technique that relay the characters’ inner thoughts and feelings. The non-linear and complex style, with shifting perspectives, has been significantly smoothed out from the initial manuscript, *Melymbrosia*, which was heavily edited to become more “readable” to the public. Part of the process of transforming the initial manuscript into *The Voyage Out* required revisions and annotations across hundreds of manuscript pages, that then had to be deciphered by genetic editors (responsible to collect manuscript versions, sorting them out, dating them, and reconstructing the writing process) for publication. English scholar Monica Latham describes the process of genetic edition as “transcribing the raw material or the authors’ working manuscripts and typescripts—difficult to read and unavailable for the majority of readers, who usually read a traditional format of commercialised books—editors and publishers have made them graphically readable, and thus allowed different types of readers to have access to them.” [84]. The editorial interventions that transform Woolf’s chaotic annotations into publishable prose enact the same fundamental operation as the translation model that process Judd’s glossolalia into “legible” and decipherable prose. Both genetic publishing and language models represent what we might call technologies of symbolic structuration: systems designed to make legible materials that resist conventional reading practices. Latham’s genetic editors, laboring to decode and transcribe authors’ “chaotic handwriting,” engage in a form of translation work that mirrors the algorithmic processes by which Google Translate convert unknown tongues into known ones—and by which large language models with a transformer architecture convert unpredictable inputs into structured responses.

Yet the apparent opposition between “human” indecipherability and “machinic” legibility dissolves upon closer inspection. As the genetic edition work shows, humans constantly engage in structuring work, while machines regularly produce outputs that confound their intended purposes [132]. The genetic editor who struggles to parse an author’s marginalia and the transformer model that generates uncanny textual continuations both participate in the continuous negotiation between structure and flow. Clifton’s embodied practice of automatic writing is a further expression of how riding the edge of legibility brings up new possibilities for interpretation, and therefore, for reconfiguration. Could the bypassing of conscious intention in Clifton’s practice (her “embodied technology”) enter into dialogue (rather than opposition) with the disinterested and disembodied predictions of transformer models? Both represent forms of technical mediation that allow meaning to emerge through processes that exceed human control, whether through the cultivation of altered states of consciousness or through algorithmic manipulations.

The Automated Writing Exercise stages this dialogue explicitly. The challenges to legibility that present stream-of-consciousness prose (its eschewing or indifference to conventional grammatical and semantic structures) meets systems specifically designed to impose such structures upon text. The result is neither human expression nor mechanical reproduction, but something more complex: a form of collaborative meaning-making that reveals the interpretative labor embedded in all technical processes of reading and writing.

5.3 The Automated Writing Exercise

In this section, I discuss the Automated Writing Exercise in more details, using one specific self-guided experiment conducted in the winter of 2025. For this experiment, I followed the constraints imposed in other versions of the exercise: a ten-minute session of uninterrupted, continuous writing produced the “seed text” which was then extended through different large language models.

For this experiment I chose to run open-source models locally on my own machine using GPT4All by Nomic [55] (see 5.5), an interface that allows users to test various freely available models without relying on external servers. This choice to work with smaller, local models for this experiment was made for several reasons: first, the performance of cloud-based models like OpenAI’s GPT-4 was a hindrance more than a boon to this exercise, as it transformed the more “disheveled” stream-of-consciousness writing into a “median” prose that erased all asperities of the initial text rather than amplifying or developing them. Second, the choice to work with local models was an extension of the larger methodological stance of this dissertation. Just as printed text or computational means create particular material conditions for interpretation, so too does the way a large language model is hosted, accessed, and engaged with. Running models locally allowed for more control over the parameters of generation and, perhaps just as significantly, demanded more engagement with the limitations of the models themselves, given that smaller models require better contextualization and more specific prompting.

Beyond questions of access and control, this experiment was also motivated by a desire to systematically explore the variations that emerge in algorithmic writing when using different models, parameters, and instructions. Conducting a stylistic/textual analysis of

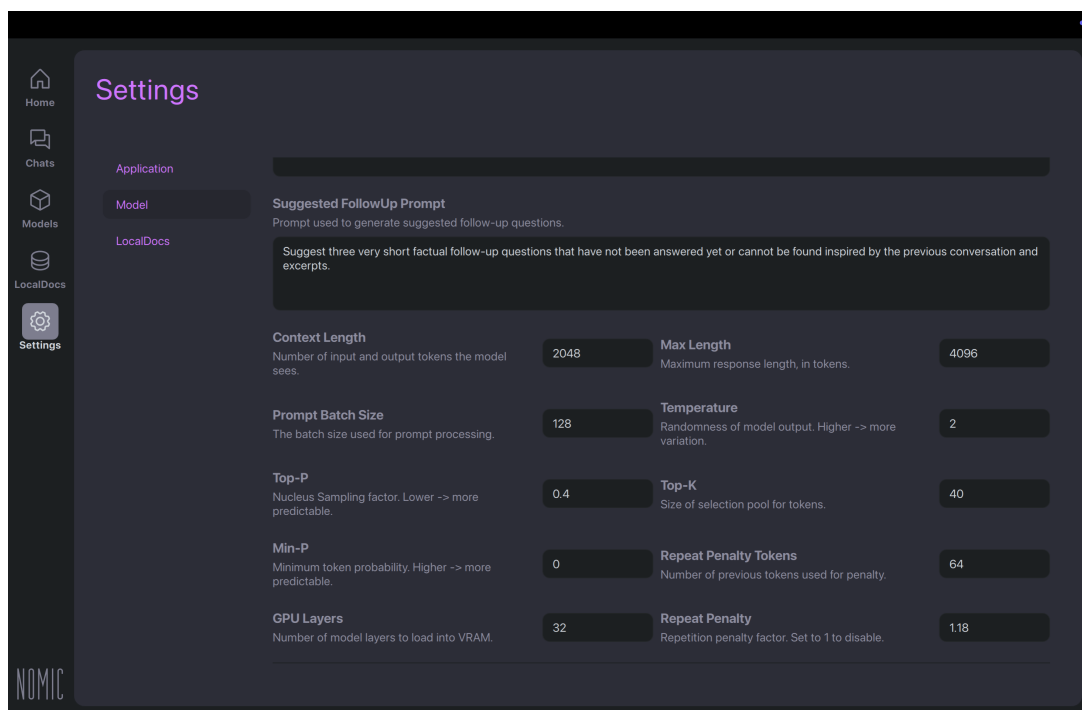


Figure 5.5. GPT4All by Nomic. Model settings can be adjusted, including system message and temperature.

various models’ outputs has much appeal as a yet unexplored form of LLM evaluation: to consider not just how “fast” a model could write and how “accurately” it could analyze and summarize text, but to pay attention to the quality of the prose, and what kind of “voice” it generates. The experiment became an exploration of textual orientations: what kinds of voices do these models enact? What rhythms, syntactic structures, and narrative inclinations emerge under different constraints? Rather than evaluating large language models’ output in terms of accuracy or correctness, through benchmarks this study considers the aesthetic and therefore expressive quality of the prose, the subtle ways in which different models shape, extend, or transform an initial passage. By working across multiple models, tweaking system messages, and shifting temperature values, I sought to explore how LLMs perform certain types of aesthetic logic, and how those influence the final composition.

Experimental Setup

The Automated Writing Exercise is structured through the following steps:

1. The writer begins by writing for 10 minutes without stopping.
2. The resulting text is then used as a prompt a large language models.
3. (Additional step for the self-guided iteration) Since I used several models for the same seed text, each model was tested under different temperature settings (ranging from 1.0 to 2.0) and with variations in system messages to fine-tune their outputs.

Iterative Machine Writing

The outputs of this experiment are best read in succession. In fact, the iterative process of using the same prompt several times for different models highlighted the cumulative effect of tweaks in model parameters and system instructions. That is, rather than considering each output in isolation, I was reading them one after the other, making subtle changes to the models' instruction and parameters to see what changed. This makes each machine output as kind of textual “swatch” which reveals the material behavior of different models. The analysis below follows this progression of outputs, beginning with the first iteration using Nous Hermes 2 at a conservative temperature of 1.5 and concluding with DeepSeek R1 at 2.0.

List of the iterations in this experiment:

1. Nous Hermes 2 at temperature 1.5
2. Llama 3 at temperature 1.5
3. Nous Hermes 2 at temperature 2.0
4. Llama 3 at temperature 2.0
5. Llama 3 at temperature 2.5
6. DeepSeek R1 at temperature 2.0

A Note on Form, Style and Content in Text

Form, style, and content are interrelated but distinct dimensions of writing and it is helpful to differentiate them before I dive into the analysis. Form refers to the structural and linguistic elements that shape a text, including sentence structure, syntax, and overall organization [81]. It also encompasses tone (the emotional or rhetorical stance of the text), and linguistic register (formal, informal, poetic, academic, etc.), among others. I understand style as a subset of form. Style refers to the particular ways the formal elements of the text are used, through for instance diction, rhythm, and figurative devices. Style is, in this sense, tied to rhetoric, in that it refers to the use of language to create particular aesthetic and cognitive effects, whereas rhetoric is the art of speech to produce certain persuasive effects. Argumentation is always an aesthetic affair. Content, by contrast, pertains to what the text is actually about: the ideas, themes, arguments, and references it contains. In my analysis, I distinguish between the formal aspects of LLM-generated text—how it enacts a particular tone, register, and stylistic tendencies—and the content dimensions, which involve the substance of what is being said, including any introduced themes, ideas or references.

Textual Analysis

In the first iteration, using Nous Hermes 2 at a temperature of 1.5, the model produced a text that was notably stable and formally coherent. The output followed the syntactic structure and lexical choices of the seed text without introducing any glaring inconsistencies or grammatical errors. In fact, the formal “perfection” of the artificial text clashed somewhat with the untidiness of the seed text. What the model retained best from the seed text was not tone or style but the theme (one of many) of being exposed through

writing, or writing as a kind of unveiling:

“The idea of sharing our subconscious thoughts and feelings with others is intriguing but also daunting. There’s a vulnerability that comes with baring one’s soul, exposing the inner workings of our minds to scrutiny. Yet, it could be liberating too - like breaking free from societal norms and expectations.”

The theme of sharing with others—whether a text, the exercise, oneself—reappeared across all outputs, regardless of the models and parameters. The next iteration used Llama 3 at the same temperature (1.5). While still generally stable, the text took on a distinctly more enthusiastic tone, departing slightly from the neutral flow of the seed text. More notably, the model introduced a self-aware reflection on the writing process itself, referencing “this stream-of-consciousness exercise in all its messy glory.” This tendency to acknowledge the exercise was also a recurrent feature of all the outputs, as if the models needed to situate themselves or provide context for the reader to situate themselves within the text. One striking artifact across all model outputs was their tendency to introduce paragraph breaks, even when instructed to produce continuous, stream-of-consciousness writing. When the temperature was increased to 2.0 in the third iteration, again using Nous Hermes 2, the text was divided into four distinct stanzas, each 2-4 sentences long. Line breaks are very important in poetry, indicating rhythm and inserting pauses where the reader might otherwise continue reading according to grammatical rules. Here, the break of the text into ‘manageable’ chunks suggests an inherent formalization of stream-of-consciousness writing, reinforcing progression and readability rather than textual overflow. The text is “reined in,” even when mimicking a freer type of writing. Beyond this formal tendency, a thematic throughline emerged across these first iterations: writing as a means of perceiving the invisible (“divinity, intelligence, even insanity”):

“We’ve associated writing and good writing in particular with gods, with geniuses, with oracles. And what if we’re wrong and in fact the divine, the god-like is actually unintelligible, ineffable, opaque? There is a quality of speech that says I am human and one that says I am animal or I am god or I am something else, something new entirely.”

In the models’ outputs, however, this reference to “gods” became indeed something else entirely: sometimes the “subconscious”, sometimes the “collective unconscious,” and in more poetic moments, “the mysterious and the sublime.” Llama 3 at 2.0 was in fact much more poetic than Llama 3 at 2.5 (a small temperature increase). Yet, the images were trite, such as when it described the feeling of diving into the Automated Writing Exercise: “It’s both exhilarating and terrifying at the same time – like standing at the edge of a cliff, feeling the wind in your hair, and wondering what lies beyond.” At higher temperature, the model dropped the poetic flourish and came back to a more matter-of-fact, almost flat tone. It used the same metaphor twice. It again included a meta-commentary on the exercise itself, directly referencing the stream-of-consciousness writing. Unlike Nous Hermes 2, which introduced external subjects and rhetorical flourishes, Llama 3 at this setting centered the text around the linguistic process that generates the text: “The exercise continues, and my thoughts begin to meander through memories, emotions, and

ideas like a river flowing through the landscape of my mind. The words start to blur together, forming strange patterns and connections that defy logic or coherence.” Except, nothing ever defied logic or coherence in any of the artificial text.

Finally, the experiment concluded with DeepSeek R1 at temperature 2.0, a model that is known for its reasoning abilities and for showing part of its reasoning in natural language. Interestingly, DeepSeek read my system message (“Continue any writing the user inputs as if you were them. Write in a stream-of-consciousness manner”) not as instructions to it but as contextual information about me. Below is the first line of reasoning of the model:

“Okay, so I’m trying to understand this exercise where the user is supposed to continue writing as if they were themselves. It’s a stream-of-consciousness style, which means just letting thoughts flow without much editing or structure. The initial part talks about how different it feels to write at home versus in an academic setting. Hmm, that makes sense because when you’re at home, maybe you don’t have the same pressure as school where grades and correctness matter.”

Rather than continuing the passage in a fluid, associative manner, the DeepSeek R1 model treated it as an object of analysis—of reasoning—attempting to determine my intent and extract meaning from the input. It interpreted the task not as generating stream-of-consciousness text but as understanding why the user had written in that way. The output eventually took the form of a bullet-point summary, listing what it identified as the key points of my seed text. This response is very different other models, which all followed the system message as instructions to them, not to me. But DeepSeek framed the task as a problem-solving exercise. This suggests the mode of interaction is in part determined by the architecture of the model, which in turn influence the prose style of generated text.

These iterations illustrate how writing with LLMs is an ongoing negotiation between the model, the system instructions, the prompt, the parameters, and the outputs. The introduction of different temperatures did not make the models more “creative” in a straightforward sense. The results were more erratic: sometimes more poetic at lower temperatures and more conventional at higher ones. Some models responded by expanding the scope of the writing, incorporating new rhetorical registers, while others became preoccupied with establishing context, producing self-referential loops that blurred the boundaries between text generation and text analysis. In this experiment, text became for me a material to recombine and transform content, closer to a process of collage than wordsmithing. Incorporating several models and iterations in the exercise made it an exploration of the expressive capacities of each model. It became an exercise in finding out what kinds of textual subjectivities do different models enact, and how to use them to their best possible effect. How do each model intervene in, reshape, or redirect the original writing? This experiment suggests that these questions are both technical—seeking to understand models architecture’s influence on writing—and *hermeneutic*, seeking to develop a personal grammar of large language model writing based on iterative exploration and interpretative engagement.

Model Selection: Brushes and Strokes in Computational Writing

Every large language model carries the weight of its own training history, its own statistical adjustments to language and discourse. While models are designed to be general-purpose, they each possess distinct stylistic tendencies, shaped by their parameters and datasets. I approached each model like a distinct type of textual “brush,” applying a different texture to the text it extends.

Beyond model selection, two additional parameters played important roles in shaping the outputs: the system message and temperature settings. Initially, I noticed that the models defaulted to a conversational tone, anticipating a back-and-forth exchange with a user, which was an artifact of their general-purpose training, unless explicit instructions are given, chat-based models tend to assume an interactive context, often shifting into explanatory or didactic speech. To counter this, I introduced a system message explicitly instructing the model to continue my writing in a stream-of-consciousness style. This intervention immediately changed the dynamics of the generated text, forcing the model to sustain the flow of prose rather than analyzing it.

The second adjustment was temperature, a parameter that determines how deterministic (or stochastic) the model’s output will be. At lower temperatures (around 0.7-1.0), the model’s responses were stable and linear, tending toward conformity with the seed text. At higher temperatures (2.0 and beyond), the outputs became more “creative” and stray farther from the seed text and the statistical norm of the model’s training data. The text that emerges from this experiment is the result of a continual negotiation between these four “parameters”: seed text (or prompt), model, system message, and temperature. The experiment, then, was about encountering the specific materialities of each model, and to observe how they extend (or distort) the writing process.

5.4 Iterations of the Automated Writing Exercise

Between 2022 and 2024, I ran the automated writing activity four times: three times in classroom settings—first in a speculative design module within a design methods course, then titled *On the Bias*, an interdisciplinary class on algorithmic bias co-taught and co-developed with professors Daniela Rosner and Afroditi Psarra—and once as a workshop for a Data & Society research event in May 2023 [35]. I followed a similar structure for each iteration: I asked participants to engage in a ten-minute session of stream-of-consciousness writing, after which their texts were extended using a large language model. The models used were various iterations of OpenAI’s GPT, from GPT-2 in 2022 to GPT-4 in 2024, and each time I noticed important shifts in how each model extended the human-generated text. These shifts reflected the rapid technological developments in machine learning, and in the context of the Automated Writing Exercise, revealed underlying tensions between unpredictability and control, and (linguistic) expressivity and correctness. From the earliest iterations, the exercise demonstrated how different versions of large language models introduced distinct aesthetic possibilities, as discussed in the previous section. GPT-2, with its idiosyncratic turns of phrases, frequent non-sequiturs, and often shaky understanding of physics, often produced text that had a distinct flavor. It was like a very smart child parroting adults, replicating their speech perfectly but without true understanding of what the words meant. The “shakiness” of

GPT-2 made it an compelling creative partner, embracing discontinuity in a way that invited a wide range of users, such as artists, comedians, writers [138, 114, 9], and data scientists [132] alike, to engage with it—to humorous and aesthetically interesting effects. To be shaky, or trembling, is to be unstable, perhaps even unreliable. There is a lack of accuracy in shakiness. Yes, this lack of accuracy is exactly what often introduces extra space between the elements of traditional and “correct” linguistic expression, enabling opportunities for aesthetic and semantic reconfigurations. By contrast with GPT-2, GPT-4, deployed in the last iteration of the exercise, had lost all of the nonsensical aspects of earlier models. Its responses were polished and structured, perfectly correct. As such, it functioned less as a vector of experimental writing and more as a writing assistant, one eager to bring that clarity to the writing. As I discuss in the next section, this somewhat defeated the purpose of automatic writing, whose interest lies exactly in the glitchy prose of a more free-flowing and associative state.

Below I describe four iterations of the Automated Writing Exercise conducted between 2022 and 2024.

First Iteration: Design Methods Course

The Automated Writing Exercise was first introduced in 2022 as part of a speculative design module within a design methods course taught by Daniela Rosner. This initial experiment sought to explore the intersection of digital technology and speculative and divinatory activities. The course featured a mix of undergraduate and graduate students.

Following the usual process, students were asked to engage in a ten-minute stream-of-consciousness writing session, producing freeform, unstructured text without constraint besides one: they couldn’t stop once during the whole 10 minute period. The theme of the text was up to them. Their writing was then input into Inferkit [77], a text generation tool built on OpenAI’s GPT-2, which extended their original prose. The results were often surprising, a little uncanny, and very personal.

The GPT-2’s generated text was striking in its ability to echo the thematic content of the students’ input while subtly shifting its voice and logic. The model was not always continuing the text in a straightforward manner but was interpreting the seed text’s tone to infer content, which makes sense. The AI-generated text was indeed an interpretation of the original text, picked among a variety of possible outputs. A sad tone became a depressed voice and talked about life hardships; a particular concern was extrapolated as being personal or professional in nature based on the language used in the text. This often resulted in outputs that felt both familiar yet alien, capturing the essence of the student’s style but infusing it with an otherness that was difficult to categorize. Some outputs contained grammatical inconsistencies and syntactic idiosyncrasies that were consistent with the input text. Repetitions were clearly kept as stylistic choices, rather than textual glitches caused by the pressure of non-stop writing. For most students, the text was puzzling because it felt both connected to them and alien: clearly the algorithmically generated prose was not their own, but still had been prompted by them. Which parts were amplified, and how was their indirect prompt interpreted by the model? Students generally had mixed reactions to the exercise. In general, the mood was cautious, and considering. There was a mix of interest and reluctance in seeing their thoughts transformed by the LLM. Due to the intimate nature of the seed text, there was a noticeable reluctance to share outputs with the class. One student shared, with dismay, that al-

though she had made no mention of her home city in the text—Chicago—the name of the city appeared in her AI-generated text. Was it a coincidence? It made her reread her initial text to look for clues that might have given it away, but she could find none. Unlike traditional collaborative writing exercises, where authorship is explicitly shared and negotiated and the decisions can be traced back to an author, the involvement of a machine added a layer of ambiguity to the ownership of the text. What was “her” in this text—a reflection of herself, revealing aspects unbeknownst to her—and what was algorithmic patterns? And what did they reveal?

The first iteration of the exercise also sparked discussions about the relationship between writing and consciousness. Some students noted parallels between the AI-augmented writing process and the surrealist tradition of automatic writing, in which spontaneous, unfiltered expression was used as a means of accessing the subconscious. The exercise felt like some sort of textual Rorschach test, they said. The comparison led to a broader conversation about the role of writing as a cognitive technology—how it structures thought and, in this case, facilitates a unique kind of attunement to language’s generative potential. Could writing express what was not yet known?

Second Iteration: *On the Bias* course

The exercise was repeated in 2023 in the *On the Bias* course, now called *Material and Cultural Bias in Algorithmic System*. The course was taught that fall by professor Rosner and brought together undergraduate and graduate students from Human Centered Design and Engineering (HCDE) and students from the department of Digital Arts and Experimental Media (DXARTS). The exercise’s setup remained the same: students wrote for ten minutes, and their texts were extended using Inferkit, which was running on early versions of GPT-3 at that time. Despite the consistency in process, the second iteration introduced subtle shifts in student engagement and interpretation. First, by 2023 AI-generated text had become more familiar to students, thanks to the release of ChatGPT by OpenAI in late November 2022, making the very notion of such tools much familiar and accessible. Contrarily to previous iterations of the exercise, many students had already encountered LLMs tools in other contexts, such as school or casual experimentation. This increased exposure led to a slightly different reception of the generated outputs in terms of attitudes: the students were not as reluctant or puzzled, but ultimately, their reactions to the output was the same: the model exaggerated elements of their voice and muted others, and it led them to go back to their seed text to find which elements were theirs and which were algorithmically generated.

Between these two iterations, a shared thread begins to emerge: the weaving (or remixing) of human voices with algorithmically generated ones and the kind of disturbance of the self that this creates. In a sense, this is not very dissimilar to Clifton’s practice of automatic writing, which also creates a kind of disturbance of the self—an opening—through which other voices can be heard and move her body to express themselves. It is also comparative to Virginia Woolf’s stream of consciousness voices in both *Melymbrosia* and *The Voyage Out*. What else is first-person fiction if not an embodiment of other voices?

Third Iteration: Data & Society Workshop

The third group iteration of the Automated Writing Exercise was in 2023. This iteration took place in the context of a workshop at the Data & Society research institute centered around the theme of “digital doppelgangers” [35]. Founded in 2014 by danah boyd, Data & Society conducts interdisciplinary research that examines how data-driven systems and AI impact different aspects of society, including labor, privacy, governance, equity, and public discourse. Here, the exercise was incorporated into a broader workshop designed to explore self-representation through algorithmic tools. For this workshop, we (Daniela and I) framed automated writing through the lens of self-making, essentially viewing LLMs as technologies of the self [49] and asking participants to use machine learning as a means of producing self-portraits.

Many participants found the exercise highly generative, even insightful—especially the automatic writing part. Some were surprised by how the model exaggerated or amplified particular elements of their voice, making their writing sound more intense or dramatic. One participant, an Assistant Professor, remarked after seeing her output: “It thinks I’m writing a dissertation.” Her original text had been a freeform reflection on a large research project she was struggling to finish, and the model extended it in a way that reinforced her sense of struggle, while reinforcing the academic context. This tendency of the model to push the more free-form writing into established rhetorical frames was a topic of discussion among participants.

The first phase of the Automated Writing Exercise proved to be one of the most generative aspects of this project. While going through the automatic writing part of the exercise, one participant coined a term that they ended up using later in their presentation at the research event. This generativity of the automatic writing, however, was brought into a certain tension with the kind of more puzzling or opaque transformations of the LLM.

Fourth Iteration: Design Methods Course

The last group iteration of the Automated Writing Exercise took place in 2024 during a design seminar at the University of Washington, led by Daniela Rosner. By that point, rapid advances in AI technology had changed the landscape once again: Inferkit was no longer available, and students were familiar with LLMs. Unlike earlier iterations, where students engaged with a relatively niche web-based tool, i.e. Inferkit, this time they used popular chat-based interfaces such as ChatGPT and Microsoft’s Copilot. The fact that these tools were now more accessible and familiar altered the dynamic of the exercise in one important way.

The biggest change was how the model suddenly produced highly polished prose. GPT-4, the engine behind ChatGPT at the time, generated text that was so grammatically perfect and “proper” that it erred on the side of insipidity and meaninglessness. The quirks and hesitations of the initial text were smoothed out, making the text feel impersonal. This “improvement” of the general-purpose model introduced a new tension into the exercise. Whereas earlier models like GPT-2 had brought their own aesthetic leanings into the writing process, GPT-4’s responses tended to provide a gripless aesthetic, making the text feel generic and unrecognizable to the participants. This change led to a discussion about the tension between writing as productive and writing as exploration,

especially in an academic context: did we write to produce (papers, grants, intellectual contributions, etc.) or did we write to explore ideas and, in this case, unknown thoughts and inner climates?

Machinic Extensions of Process: Reflections

Writing is an externalization of thoughts, and there is the misconception that therefore the process for writing is simply to write down what it is that we think. But anyone who has ever written more than a few sentences knows that the process is less straightforward. As words find their shape of the page, so does the shape of our thinking change. Although writing gives the impression of fixity, the process is always undulatory, moving between thoughts, hand, and page in a call-and-response that is as physically demanding as dancing. It is tempting, therefore, to offload some of the cognitive and physical strain of writing, of figuring out the best shape of our thoughts, to algorithmic generation. But when the goal of the exercise is to find no particular shape—or rather, to let the shape be defined by the flow of the hand on the keyboard, or on paper—the role of LLM becomes something other entirely: by continuing the shape of the initial writing, which is in itself of an exploratory nature, the language model enables the externalization of a thought-in-process, or rather, of thinking (the process) rather than a thought (a temporary but fixed expression of thinking). In this sense, the Automated Writing Exercise can be viewed as the textual form of Chinese-Canadian artist Sougwen Chen’s *Drawing Operations* series [26], in which her drawing movements are captured by a camera, analyzed through computer vision software, and relayed to a robotic arm that mimics her drawing style (see Figure 5.6).

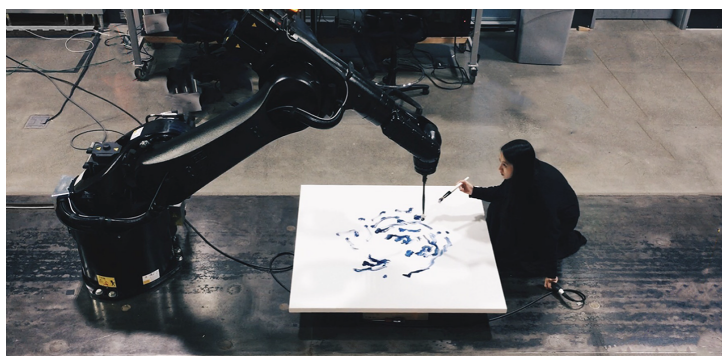


Figure 5.6. Artist Sougwen Chen *Drawing Operations* piece (2017), in which a robotic arm mimics the artist’s gesture analyzed through computer vision software. Image from the artist’s website.

The “illegibility” of the automatic writing process is in fact not so much illegible than *in-progress*. Clifton’s automatic writing process was in this sense a way of making contact, of establishing a path towards the other or something other. When asked about why she wrote, Lucille Clifton said: “[Perhaps] for me it is a way of remembering I am not alone. And the writing may be sending tentacles out to see if there is a response to that” [31]. Writing is relational, and so is legibility. Legibility is not so much an attribute

of artifacts than the expression of a certain relation between reader and artifact (whether textual, spiritual, or machinic). In this sense, perhaps what is true of spirit-infused writing is also true of machine-assisted writing: both are not so much about the text than about the experience. Both practices are about sustaining a conversation between mind and page, between selves, perhaps between intelligences. Is it that conversation which shape what can be thought.

5.5 Writing with Code(s)

I situate the Automated Writing Exercise explored in this chapter within the broader lineage of computational poetics, a tradition that treats text generation as an aesthetic, material, and technical practice. Computational poetics is about the material transformation of language using manual and/or algorithmic techniques, as well randomness. This attention to the materiality of textual forms in digital environments make computational poetics not just a practice but a “strategy of interpretation capable of reaching past surface content to reveal platforms and infrastructures that stage the construction of meaning” [152] From early experiments in constrained writing to contemporary neural networks, computational poetics provides historical and aesthetic framework for understanding how machines and language are entangled.

Procedural approaches to writing have been around for a long time. In the 13th century, the Jewish mystic Abraham Abulafia developed a system of letter permutation based on the *Sefer Yetsirah*, believing that structured linguistic manipulation could reveal divine insights [109]. In the late 17th century, German philosopher Gottfried Wilhelm Leibniz would be inspired by another 13th century mystic with a penchant for combinatory linguistic practices, a Majorcan philosopher named Ramon Llull who developed a system of logical and linguistic combination that is considered one of the earliest examples of algorithmic thinking applied to language [leibniz_2019]. Llull’s work introduced a mechanical method for reasoning, using concentric wheels inscribed with letters representing divine attributes and philosophical concepts. These wheels could be rotated to create different logical combinations (see 5.7).

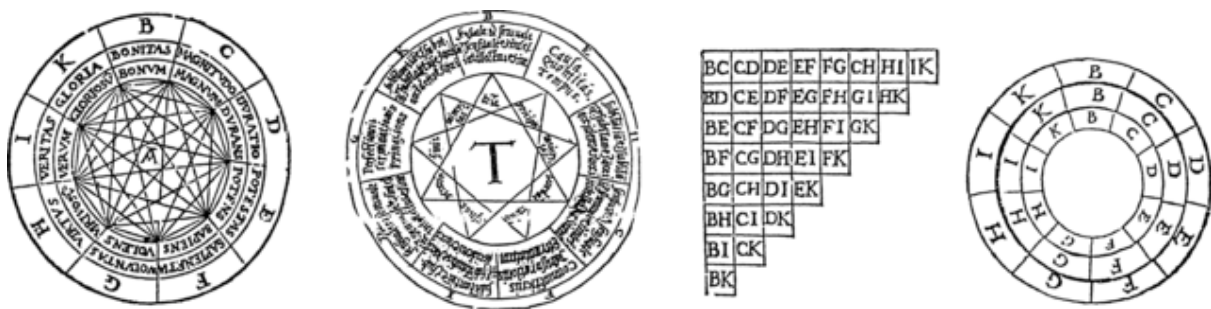


Figure 5.7. Ramon Llull’s *Ars Magna*, Fig. 1-4. Public domain.

In the 20th century, several combinatory and procedural approaches to the manipulation of language were developed and formalized by the French artistic movement OuLiPo. The OuLiPo, an acronym for *Ouvroir de littérature potentielle*, or “Opener of Potential

Literature”, was formed in 1960s France, and its members approached writing as a combinatorial, rule-based system [124]. Figures like Raymond Queneau and Georges Perec experimented with formal constraints, crafting texts that emerged out of the limitations imposed on them.

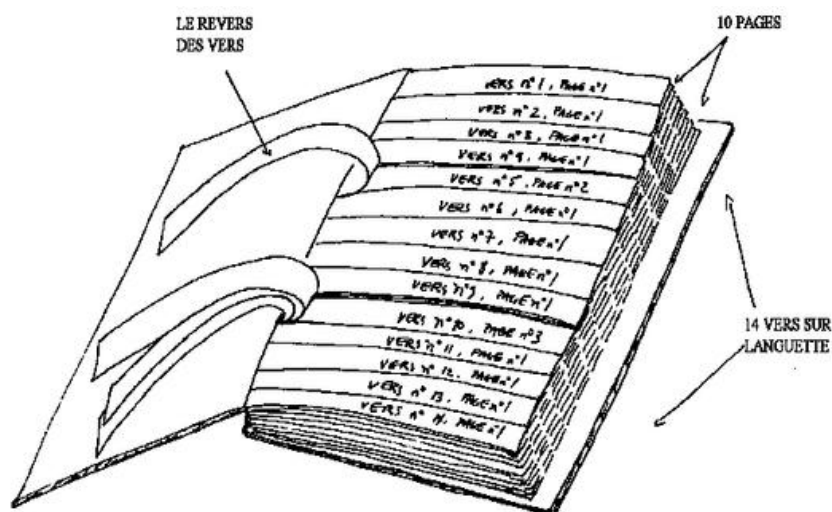


Figure 5.8. Raymond Queneau’s *Cent mille milliards de poèmes* (1961), a work of combinatorial poetry. Ten sonnets, with each line printed on its own strip of paper which the reader can turn at will, create the “one hundred billions poems.”

In the digital era, early experiments in computer-generated poetry built upon these ideas. Pioneers such as Alison Knowles, who co-created *A House of Dust* (1967) [79], and Christopher Strachey’s Markov-chain-generated love letters (1950s) [147] demonstrated how computation could be used to generate poetic forms of expression. Later, digital poets like Nick Montfort, John Cayley, and more recently Allison Parrish further expanded the field, leveraging rule-based systems and machine learning to interrogate the materiality of text and the role of algorithms in poetry composition.

Contemporary computational poetics practices make of machine learning, artificial intelligence, and large language models (LLMs). For instance, Parrish’s 2019 project *Pincelate* is a machine learning model for spelling and sounding out English words [118]. But in the few years between Parrish released this project into the world and the writing of this dissertation, machine learning has changed considerably. The increasing use of LLMs for text generation introduces new questions about the aesthetics and politics of machine-generated writing.

The Automated Writing Exercise extends these traditions by layering different forms of (letting go of) control. By relying on the generativity of automatic writing, and then of algorithmic text generation, the exercise sits somewhere at the intersection of the Surrealist movement’s interest in subconscious expression, and the OuLiPo’s focus on rules and procedural techniques. Unlike the OuLiPo movement, which embraced formal constraints as a generative force, treating writing as a combinatorial, rule-based system,

```

The House of Dust (1967)
based on a work by Alison Knowles & James Tenney
code by Nick Montfort, also in Python 2/3
from Memory Slam 2.0: Batch-Era Text Generators

A house of straw
  In a hot climate
  Using all available lighting
  Inhabited by little boys

A house of roots
  In dense woods
  Using all available lighting
  Inhabited by lovers

A house of mud
  In a hot climate
  Using electricity
  Inhabited by people who eat a great deal

A house of steel
  In a metropolis
  Using all available lighting
  Inhabited by people who love to read

A house of mud
  In an overpopulated area
  Using electricity
  Inhabited by very tall people

A house of paper
  In a green, mossy terrain
  Using all available lighting
  Inhabited by people who love to read

```

Figure 5.9. Alison Knowles’ *A House of Dust* re-imagined by Nick Montfort. [Full piece here.](#)

surrealism sought to bypass rational control entirely, using automatic writing as a means of channeling unconscious thought. Where OuLiPo foregrounded material constraints, surrealist automatism was about surrender, allowing language to surface without conscious interference. André Breton, a leading figure of the movement, wrote that just as contemporary physics sought to re-establish itself on non-Euclidian bases, the creation of surrealist objects was an answer to the necessity of establishing a “physics of poetry” on non-rationalistic foundations [40]. The project of bypassing the rational mind that had dominated Western intellectual and cultural life since the Enlightenment was also a response to the growing fragmentation of post-industrial modern life and its increasing mechanization.

If contemporary machine-generated text tends toward predictability and standardization—towards “good” and fast, that is, productive writing—then the Automated Writing Exercise can serve as a counter-practice, actively subverting these tendencies, and it does so by foregrounding the materiality of machine writing. In the transition from human hands to neural networks, a redistribution of authorship occurs, across an assemblage of textual constraints, algorithmic logics, and cultural values embedded in machine learning models. Much like the experimental poets before them, participants of the Automated Writing Exercise were invited to consider writing and text-generation as both expanded and contested by the affordances of computation: expanded because it artificially sustains the writing process and contested because it also profoundly altered the *thought process* at play in the original text.

In the interplay between automatic writing and automated writing, we encounter a shift in the locus of embodiment, from the writer bypassing conscious control through speed to let the “body speak,” to yet another surrender of the body this time to a dis-

tributed computational infrastructure taking over the material act of inscription (LLMs). Writing is, first and foremost, an embodied practice. Writing can happen without the mind being fully “there,” hovering over every word. This phenomenon is amplified with automatic writing, and later with LLMs, where human bodies have a more distant involvement with the generation of text. If automatic writing gestures toward a kind of spiritual surrender, an openness to other voices and forces, then writing with LLMs situates this practice within a broader technological assemblage in which cognition, authorship, and even embodiment are radically distributed.

5.6 *The Voyage In*: Extending the Automated Writing Exercise

In lieu of a final comment, I present *The Voyage In*, an experiment in computational poetics that is both an extension of the Automated Writing Exercise (using the AI-extended automatic writing text from my self-guided iteration) and a material interpretation of the revising and editing process of Woolf’s *The Voyage Out* (1915). *The Voyage In* remixes the text through a series of bodily and digital techniques and tools for textual production and manipulations: automatic writing, algorithmic text generation, vector software, a pen plotter, and layout. The piece is called *The Voyage In* both in reference to the stream-of-consciousness passages that would become characteristic of Woolf’s writing, and because the process of engaging materially with the stream-of-consciousness writing is a form of technological *détour* that makes the “external” considerations of textual production—how a text is written, typeset, printed, bounded, etc.—the inner substance of the piece. Moreover, the text used in *The Voyage In* are the fragments produced during the self-guided iteration of the Automated Writing Exercise discussed in section 5.3, which are algorithmically generated extrapolations of the stream-of-consciousness passages characteristic of the Woolf’s *The Voyage Out*.

The Voyage Out was Woolf’s first novel. The narrative explores the limits of expression, following the protagonist Rachel Vinrace as she embarks on both a literal and metaphysical journey to South America. As E.L. Bishop remarks, *The Voyage Out* anticipates the author later experiments with language, guiding the reader to an intuitive apprehension of reality rather than relying a more traditional descriptive prose [17]. The narration attains “the concentration and suggestiveness of poetry” [17] and Woolf, even in this early work, probes the failures of language, both its capacity to evoke and to confuse, and to reveal what exists just beyond its reach.

Indeed, *The Voyage Out* is a “readable” version of a much more chaotic and audacious, perhaps “unreadable” manuscript, *Melymbrosia*, the first version of the novel. The initial manuscript underwent many revisions and alterations; it was “re-formatted, re-framed, and re-cast in a more conventional mould” [84]. According to Lantham, “the drifting, spontaneous fiction of *Melymbrosia*, which follows the chaotic and meandering train of thought of the character, may have been judged too challenging for the reading public at the beginning of the 20th century. This could be the reason why in re-writing her novel, the author aimed at a more realistic, metonymic representation of reality, thus regressing from a more adventurous, new, and original way of writing. *The Voyage Out* offers the reader a safer and more readable version” [84].

The idea of readability here concerns not just the thematic content of the novel but the very *shape of the language*, which is altered through both symbolic and material manipulation. The Automatic Writing Exercise is also, ultimately, an exercise in questioning readability, and how it is always negotiated through technical and social processes. As such, this extension of the Automated Writing Exercise through *The Voyage In* is an attempt at giving this exercise a textual “body,” a form that is manipulable and therefore, perhaps, more readable.



Figure 5.10. Excerpt from the *The Voyage In*, an experiment in overlaying different types of writing technologies and techniques from automatic writing and AI-text generation to pen plotting and book binding.

The making of *The Voyage In* began with the outputs from the self-directed iteration of my automated writing experiment discussed in section 5.3. These texts, produced using different large language models, at varying temperature settings, and with different system prompts, already exhibited a multiplicity of voices, stylistic registers, themes, and even text formatting strategies. These texts are extended in that rather than treating each model output as continuation as a finalized product, I approached them as fragments, further material for the collage-like process of writing with transformers. From here, I used the open-source vector design software Inkscape [165] to typeset the text, transform the text into machine paths, and send the paths to an iDraw A1 pen plotter [159]. Given that I was working with an existing booklet, the only way to get the pages to lay flat was to unbind the booklet and lay down the pages onto the plotter bed.

Once the layout was finalized, the text was converted into vector paths for plotting. Unlike digital printing, pen plotting is a more handmade approach to the mechanical reproduction of text. It introduces imperfections: variations in ink flow (pens dry out), shifts in line weight (surfaces are uneven), subtle misalignments that make each inscription unique.

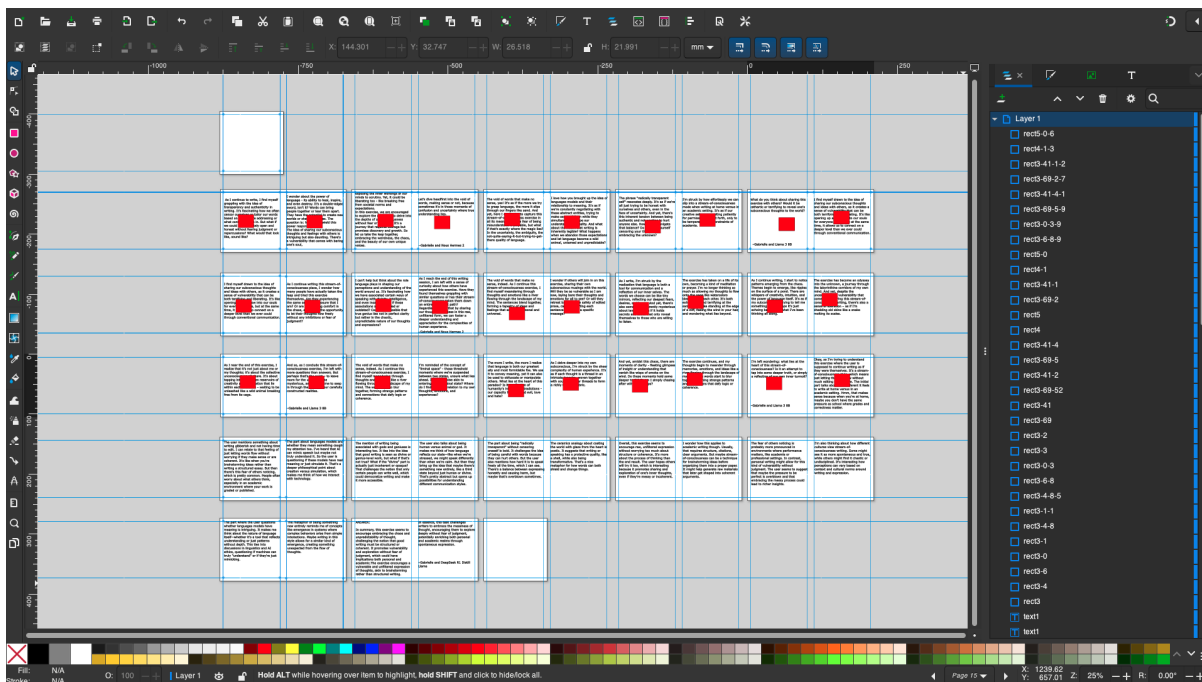


Figure 5.11. Layout of *The Voyage In* in Inkscape.

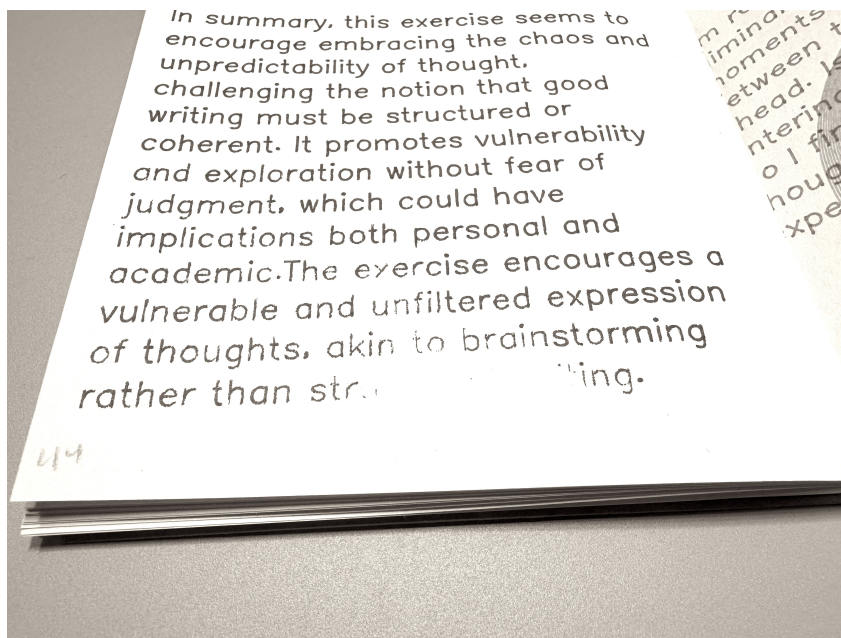


Figure 5.12. Writing glitch: uneven surfaces create variations in plotting as the pen loses contact with the page.

In this way, the plotted text places the AI-generated outputs of the Automated Writing Exercise into a chain of material and algorithmic manipulation that emphasize its existence as something made and inscribed through specific tools and processes—its situatedness. The final phase of *The Voyage In* was its re-assembly into a physical booklet, using staples.

The Voyage In is an exploration in computational poetics that does not attempt to resolve the tensions between different forms of textual inscription. Between the slippages of the automatic writing, the inaccuracies (stylistic or otherwise) of AI-generated text, the material errors of plotting, and the reshuffling of layout and book binding, it is a surprise that *The Voyage In* is legible at all. And yet, it definitely says *something*. Perhaps it says that generative and artificial writing is never simply a matter of productivity but instead an hermeneutic activity, one in which text is constantly being reconfigured through interaction with different material constraints and subjectivities (readers). Woolf's novel is concerned with the limits of language, with the ways words fail to fully capture experience, leaving the reader in a state of partial apprehension rather than full understanding. We intuit what is going on, what the novel is about, without ever being given a complete description. This is where the expressivity of the text comes from: from the gap between words and interpretation.

The Voyage In extends this concern of readability into the realm of digital textuality, questioning how meaning is shaped by the technologies that mediate it. Text, whether human- or machine-generated, is always shaped by the conditions of its production, whether those be neural network architectures, machine paths, or ink in the fibers of paper. If Woolf's *The Voyage Out* is an attempt to move “toward the far side of language” [17], *The Voyage In* is an attempt to test how far language can be stretched across computational and physical substrates, and across automated and manual processes.

Reflection

In his annotated bibliography of *Experimental Studies on the Legibility of Print*, Miles A. Tinker writes: “Legibility of print is concerned with perceiving letters words and with the reading of continuous textual material. . . . [Legibility] of print deals with the coordination of the factors inherent in letters and other symbols, words, and connected textual material which affect ease, accuracy, and speed of read” [154]. Legibility is indeed intimately tied to the material and technical conditions that make text possible. The Automated Writing Exercise is an exploration of legibility as both a social and technical process. When presented with the output of their automatic writing text, the participants of the Automated Writing Exercise found a generative form of looser discourse which, if less polished and “harder” to read, was nonetheless substantial. The automatic texts were then processed through as LLM, which either distorted, amplified, or polished the text of the participants. In many ways, the shift from GPT-2 productive illegibility to GPT-4's highly readable text showed that what is readable is not always what is most polished or technically mediated.

Through this exercise and the analysis, I distinguish between three modes of legibility in writing with transformers: material legibility, which determine how technical constraints (in this case, speed, the continuous movement of the hand, but also text and data formatting, notebooks, printing techniques) shape what can be read, and written; algorithmic legibility, which considers how algorithms manipulation inserts processes that

always invite further investigation, and; interpretive legibility, that is how signification emerges out of the gaps and failures of various technical and material manipulations (through techniques such as automatic writing, machine translation, and writing with transformers, among others.

CHAPTER 6

Hermeneutic Engineering

“If we want the revolution, it is certainly to give bread to all... . But we also expect something else from the revolution. ... [To ensure] to all these joys now reserved to the smallest minority ... the highest joys accessible to human beings: science, and especially scientific discovery; art, and especially artistic creation It is to ensure the possibility of developing one’s intellectual capacities that the revolution must guarantee to all their daily bread.”

—Pierre Kropotkine, excerpt from *La conquête du pain*, 1892 (my translation) [82].

6.1 Introduction

At the core of this dissertation is an inquiry into participation. More specifically, it is an inquiry in how participation in the landscape of technology building and development happens not just at the level of making, but at the level of interpreting, which I conceptualize as a form of re-making. Ensuring the possibility to engage meaningfully and creatively with the world is perhaps the most important political project. to realize this change there is a need to reconsider how participation is construed. To increase access to tools and resources for material participation is important, as are the epistemic practices employed daily to both make things and make sense of the world.

My own take to the question of participation is an inquiry into how people might engage with computational systems. The lesson from history I wish to bring forward comes from print culture, which shows that the development of print as a convivial technology, after Illich’s definition [68], required both technical innovation and the development of certain social practices. David Noble warned that the idea of technology had lost its “essential concreteness” and therefore “all reference to particulars of place and purpose, tactics and terrain”:

“Technological determinism—the domination of the present by the past—and technological progress—the domination of the present by the future—have combined in our minds to annihilate the technological present.” [111, p. 10]

For Noble, technological determinism and progress tend to naturalize technology, spinning a teleological tale of technical growth that obscures the manipulations and many hands that are currently making, and operating, technology. The option proposed by Noble is to take charge of the means of production, or risk being “unarmed” in the current struggle for power. My project instead frames systems as cultural sites of interpretative engagement, which require not so much a “domination” of the technological present than an attention to it, to interrogate and remake what seems fixed or inevitable.

6.2 Participation through Interpretation

Several narratives arise when discussing participation in technology. There is a push toward STEM education as a route to technical literacy [5] and the proliferation of maker spaces and fabrication tools [47]. There are also critical inquiries into the values and narratives that undergird these paths to technological innovation and participation [6, 90]. One angle I wish to explore here is participation through material interpretation, which is a form of interpretative engagement substantiated and formalized through objects and materials. The historical example of commonplace books I will now turn to shows how participation in a given technological and cultural landscape can happen not necessarily by seizing the means of production, or by increasing technical education, but by allowing appropriation through idiosyncratic and intensely personal forms of engagement, which I argue are interpretative processes at their core.

In *Tools for Conviviality*, Ivan Illich has a lot to say about tools that are not convivial, and few examples arise of what convivial tools actually look like. He does name a few however, and memorable among them are the alphabet and the printing press (memorable for how Illich clearly articulates through them the aims of conviviality):

“The book is the result of two major inventions that enormously extended the balance of learning: the alphabet and the printing press. Both techniques are almost ideally convivial. Almost anybody can learn to use them, and for his own purpose. They use cheap materials. People can take them or leave them as they wish. They are not easily controlled by third parties. The alphabet and the printing press have in principle deprofessionalized the recorded word. With the alphabet the merchant broke the monopoly of the priest over hieroglyphs. With cheap paper and pencil, and later with the typewriter and modern copying devices, a set of new techniques had in principle opened the era of nonprofessional, truly convivial, communication by record.” [68, p.79]

It is interesting to consider the kind of world this excerpt might depict if we replaced “recorded word” with “software.” While code is also “almost ideally convivial” (anybody can learn to use it for its own purpose; it is not easily controlled by third parties), it would be an understatement to say that it is not systematically put in service of conviviality. Many digital services and systems are in fact more often accused of de-socializing: social media isolate the youth [76] and worsen mental illness [108], algorithms trap users in echo chambers that erode public discourse [144], and automated decision-making systems often reify systemic injustices [112].

What Illich’s analysis overlooks is that the alphabet and the printing press were not convivial “right out of the box” but instead became so through a long series of technological innovations and the development of social practices to integrate their norms into culture. The democratization of print wasn’t just about cheaper printing technologies but about the slow refinement of technologies that are today mostly invisible (unless you are trained, i.e. “professionalized,” to see them), such as layout and typography [87, 88]. Besides these technical developments, the development of the book as a convivial technology was equally driven by social practices of interpretation and material engagement. One of them is the commonplace book technique, which refers to the process of compiling, rearranging, and annotating textual fragments into a personal archive. The fragments of commonplacing could be sayings and maxims, excerpts from books or sermons, recipes, measuring tables, song lyrics, as well as musings, observations, thoughts, and ideas.

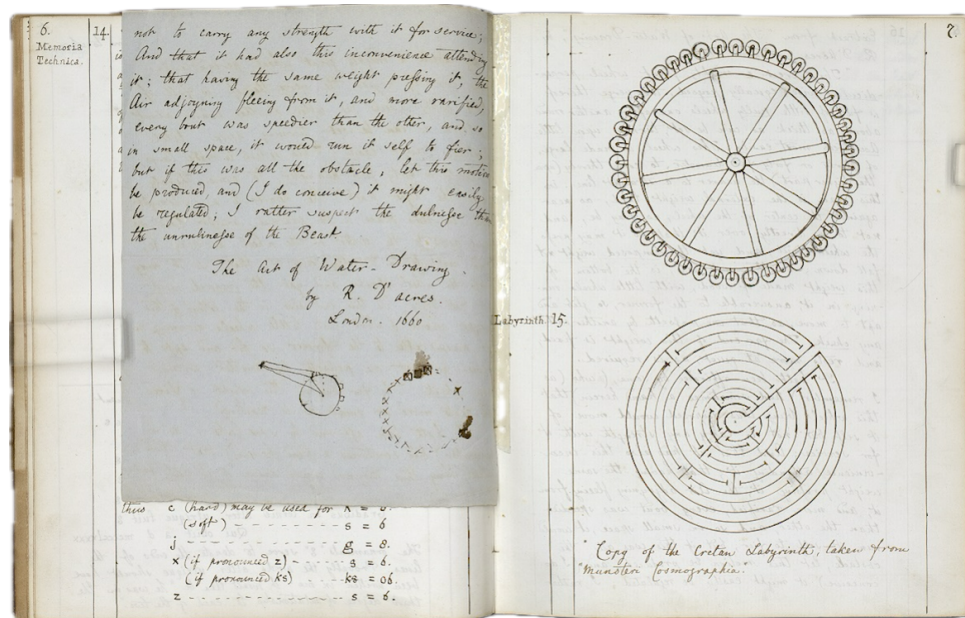


Figure 6.1. Pages from Charles Dodgson’s (Lewis Carroll) commonplace book. Credits: Harry Ransom Center

Commonplacing was a widespread practice in 19th century England, but remains an outlier in literary categorization precisely because of their heterogeneity and the interpretative labor they embody [21, 117, 107]. The interest of commonplacing to this discussion is how it increased readers’ domain of action by blurring the distinction between reading and writing; in the words of French historian Roger Chartier, “[with the commonplace technique] the readers are creating the meaning of the text, which is not necessarily the meaning intended by the author. So it’s a form of freedom—of appropriation, of invention” [23]. I would argue here that commonplacing was a form, first and foremost, of material interpretation, one which enabled the “consumers” of the information technologies of 19th century England (today we might say “users”) to become participants in the technological and cultural landscape of their day. Through commonplacing, they effectively became writers—not professional ones, but casual ones—not so much writers of commonplaces than commonplace writers.

Reflecting on this historical parallel prompts us to ask: what might contemporary forms of commonplacing look like in the realm of digital technology? How might we foster practices that similarly encourage creative intervention, interpretative openness, and active remaking? Again, commonplace writers were not professional writers, but were nonetheless participating in the cultural and technological landscape of their day. The cue I want to take from the example of commonplacing here (which is by no means an “ideal practice” but an interesting example of what kinds of social practices evolved in the context of print culture), is rather than framing technological participation as only mastering tools or acquiring coding skills, we might imagine new kinds of technological engagements—convivial in Illich’s sense—that empower users as interpreters, critics, and creative agents who materially reshape technology according to their own experiences, desires, and needs.

Thus, the orientation my project takes is to inquire into yet another facet of participation, both beyond and next to broader access or better education. It also requires cultivating interpretative, creative, and materially engaged forms of participation. This dissertation calls for precisely such a shift, envisioning frameworks of technological engagement that are historically grounded, interpretative, and materially expressive.

Towards a Definition of Hermeneutic Engineering

Here I will attempt a first definition of hermeneutic engineering. Rather than positing hermeneutics and engineering as distinct epistemic traditions, I suggest that the term “hermeneutic engineering” underscores a fundamental interconnection: interpretation is materially enacted, and material making is inherently interpretative. The distinction between these two registers, when examined more closely, appears largely artificial; indeed, each continuously informs and sustains the other, as in the example of commonplacing, but also of the projects discussed thus far.

This argument aligns with contemporary theories of participation, particularly those highlighting the role of objects and materiality in the enactment of public life (the “material turn” in the social sciences) [85, 62, 162]. Material participation, according to Noortje Marres, emerges precisely in everyday interactions with objects and technologies, and reveal political and interpretative dimensions that conventional, discursive understandings of participation tend to overlook [99]. My proposal of hermeneutic engineering thus resonates strongly with Marres’ call for recognizing material practices as significant—and even privileged—sites of participation. However, while Marres focuses on everyday practices such as domestic routines and energy usage, my approach extends to more explicit interventions that are materially instantiated with and through digital phenomena, such as programming environments, creative engagements with data, and interactions with large language models (LLMs). Moreover, and moving further from Marres, I frame material participation first and foremost as a form of interpretation, in which dimensions of digital encounters are singled out, investigated (however lightly), and, eventually, repurposed or reconfigured according to one’s own needs and interests.

Hermeneutic engineering therefore involves two interconnected registers. The first, interpretation, involves active engagements—selecting, questioning, and negotiating the affordances and possibilities of technological systems. The second, the engineering dimension, involves materially instantiating interpretative acts—writing or annotating code, fabricating artifacts, developing expansive types of encounters, etc. Engineering here,

does not refer to the discipline but to the verb, meaning *design and build* or *skillfully or artfully arrange* for something to occur. To engineer is to “bring about,” not just through making but also through reconfiguring things—by skillfully arranging them so that they yield new situations, new possibilities, and ultimately new meanings. This is also, incidentally, a definition of interpretation. I therefore understand engineering here as a domain of action and this action can be making, but it can also be *remaking*.

When I talk about technical participation, I don’t only mean building systems, but refer to all the activities that enable systems to remain actual in the world: extending them, modifying them, maintaining them, repairing them. This changes certain assumptions about participation itself in the technological domain, traditionally understood as acquiring a certain technical expertise. Instead, I propose to consider technical participation as a process of material interpretation, which can take the form of making tools among many others modalities of material engagement. Articulating the interconnectedness of interpretation and material (re-)invention is not without challenges. The boundaries of disciplines tend to separate interpretative and engineering practices, associating interpretation exclusively with the humanities and material making with technical disciplines. The separation between hermeneutic and engineering disciplines finds its roots in the inception of Western intellectual history, tracing back to Aristotle’s distinction between *episteme* (knowledge of principles or theoretical understanding) and *techne* (skilled, practical knowledge or craftsmanship) [119]. Hermeneutics, evolving from interpretative traditions within theology and literature, became aligned with contemplative, reflective, and immaterial practices, while engineering inherited the practical, instrumental, and material orientation of *techne*. This division has tended to obscure the intrinsic connections between these practices, as Simondon noted [136]. Hermeneutic engineering positions itself at their intersection—or more accurately, highlights their continuous overlap. As the projects in this dissertation have shown, when materials are concerned, interpretative activity is never far away. When interpretation and material making are recognized as mutually constitutive, especially in the domain of technical systems and artifacts, questions about participation expand from a tight focus on technical skill acquisition or tool accessibility to include the way technical systems can be encountered. The emphasis turns to supporting interpretatively engaged and materially experimental practices—practices inviting people to reshape technological configurations actively and creatively. From this perspective, participation is not simply about who has access or who possesses technical knowledge; it is about fostering contexts in which diverse actors can materially interpret, interrogate, and if they wish, remake technology.

The next section develops this point further, examining concretely how interpretation operates materially through diverse technological engagements. By doing so, I show how hermeneutic engineering provides a useful framework for thinking through participatory technological practices.

6.3 Interpretation as Material Practice

In *Lire, interpréter, actualiser*, media theorist Yves Citton proposes to rethink interpretation as a cultural *and* political activity [28]. For Citton, interpretation is a process that brings a text to life in the here and now by reconfiguring its significance in light of

contemporary concerns (i.e. the reader's). The interpreter, in this view, is not a decoder but a *composer*, arranging fragments and associations into new and meaningful configurations. This vision of interpretation resists the epistemology of (technical) mastery. It shifts the focus from authoritative meaning (or authorial intent) to situated engagement. Citton writes that the value of interpretation lies “not so much in bringing new information to the world—a new system, a new fact—as in reconfiguring existing elements in a way that makes them meaningful, that brings a different perspective, that enlarges possibilities for understanding and engagement” [28]. In this sense, interpretation becomes a kind of affordance: This conception of interpretation has many implications to understand participation in a technical context. If interpretation is a form of reconfiguration then materially interpreting technical systems is about the capacity to recompose their meanings and effects. Participation becomes a practice of intervening in the symbolic and material *operations* of technical systems. Citton's emphasis on reconfiguration also helps articulate why interpretation matters politically. The dominant knowledge economy, he argues, tends to reward novelty, innovation, and information production while devaluing interpretative labor. Yet it is precisely through interpretation that existing systems are made legible, flexible, and open to transformation. In other words, interpretation is not secondary to innovation but what makes innovation meaningful (valuable) in the first place. Without interpretation, novelty remains inert; without reconfiguration, information cannot generate significance. To illustrate this, Citton turns to the idea of “repartition”: the redistribution of meaning across social space. Interpretation, in his framework, is fundamentally an act of re-partitioning: it breaks open settled meanings and redistributes the sensible [122]. This resonates strongly with the political thought of Jacques Rancière, for whom politics is not about consensus but about change—about introducing dissensus into the distribution of what counts as meaningful, visible, or sayable. In the context of technical systems, this (re)distribution means systematically engaging with the “authorial” or designerly intent of systems, to question it and possibly take it apart in order to extend the system to a wider range of interests and concerns. Citton's work reframes interpretation as a way of keeping meaning *open* rather than finding a definitive signification. Hermeneutic engineering is therefore about sustaining inquiry (through creative and critical engagement) and materials (through reconfiguration, customization, maintenance, repair). As technological systems become more opaque and automated, cultivating interpretive capacities becomes an essential mode of both technical engagement and material participation.

Material Interpretation in Imprimer, Data Epics, and Automated Writing

Imprimer: Rewriting the CNC Workflow

Imprimer reframes CNC milling as a reflective and iterative practice, enacted through the medium of the computational notebook. Traditionally, CNC workflows are governed by the fairly rigid CAD–CAM–execution pipeline which, while precise and reliable, severs the feedback loops between design and execution and, ultimately, between expressive intent and material [158]. Imprimer shifts these pieces around and breaks open the pipeline. By embedding machine control inside a computational notebook environment (Observable), it repositions programming, annotation, visualization, and machine execution within a single interface. Instead of specifying geometry in one tool, generating

toolpaths in another, and executing them in yet a third, Imprimer allows work within one medium—the notebook—where these operations unfold side by side. Because Imprimer allows for rapid iteration—adjusting parameters, visualizing changes, and dispatching modified commands—the process of CNC milling becomes more conversational. The user can tweak a variable, re-run a cell, inspect the output, and respond accordingly. Each edit, each toggle of a code cell is a decision to engage with the complexity of machine programs and an opportunity to develop material intuition with machine and code.

This interpretative dimension is particularly salient in the way Imprimer toggles between visibility and abstraction. Users can expose the code underlying a milling operation or collapse it into a graphical interface. This seamfulness, as discussed in HCI literature [69], invites direct engagement with machine operations. It is in that sense that Imprimer enables a conversation between system and user: which parts of the system should be surfaced, which concealed, and when (and, possibly, why)? The user gets to shape a received design environment in practice. In this way, the notebook is not just an archive of the design process (although it is that too!) but a site of reading and writing, of execution and reflection. As I argue in Chapter 3, Imprimer extends the legacy of analog notebooks into the domain of machine control. In this sense, Imprimer enacts a hermeneutic approach to digital fabrication. It does not eliminate complexity, but makes that complexity legible—readable, writable, and reconfigurable. In doing so, it affirms that interpretation is a constitutive act that takes place within and through material practice.

Data Epics: Reconfiguring Data Through Narrative

If Imprimer reconfigures the interactional modalities of CNC milling, Data Epics reconfigures data itself, through narrative. In this project, datasets gathered from domestic smart devices were transformed into short stories by fiction writers, in collaboration with the data-producing households. Our goal was to explore data’s interpretative and expressive potential—to expand data imaginaries. What happens when personal data is treated not as evidence for facts, but as material for fiction?

This project foregrounds interpretation in its most expansive sense. As Johanna Drucker and others have argued, data is not a neutral record of the world, but is always already structured by tools of capture, formatting conventions, and representational techniques [45, 32, 66]. The Data Epics expose the myth of “raw” data by shifting the interpretive frame: instead of treating data as information to be extracted, the stories treat data as a material to be shaped. This act of reimagining is an interpretation, both conceptually (by expanding data worlds and narratives) and materially (by reconfiguring data representation). To the confusion of many participants in the study, The Data Epics did not attempt to restore context or recover “what really happened” in the household. Rather, the stories created in the project proposed alternate contexts and imagined realities that emerge from the the data and their interpretation. The Data Epics are, in other words, interpretations of data. As such, data did not act as the record of behavior participants of the project expected, but a prompt for world-building. By crafting fictional worlds from domestic data, the Data Epics open up a space in which data becomes legible and act as material for more expansive encounters with IoT devices. In doing so, the stories create a terrain of participation: the home dwellers shifted from being only producers of data and instead became creative interpreters: from the manipulations required to access the data, to the strategies to remake it. Participation becomes less

about control or transparency (reading the privacy clauses on user agreements—“what of myself can be known?”) and more about interpretative authorship: the right to see oneself differently in the mirror of the machine (“what selves are we co-creating?”).

Automated Writing: Recursive Interpretation Across Human and Machine

Where *Imprimer* works through fabrication and *Data Epics* through narrative fiction, the Automated Writing Exercise explored interpretation in recursive dialogue with language models. This exercise, deployed in classroom settings and public workshops between 2022 and 2024, asked participants to engage in two phases of writing: first, a 10-minute stream-of-consciousness freewrite (or automatic writing), and then a continuation of that text using a large language model (LLM). The juxtaposition of these two modes—human automatic writing and machine-automated text generation—created a layered writing process that unfolded through both material and algorithmic inscriptions.

Automated Writing is, of course, an exercise in both human and machine interpretation, and what happens when they overlap. In the initial freewrite, the human writer taps into a different mode of writing where speed and flow prevail over coherence and structure. Reading the text generated this way is itself a reading of technical processes—in this case, of the embodied technology (to use Bettina Judd’s term [74]) of automatic writing. When this text is passed to a language model, a second act of interpretation occurs, this time machine interpretation. LLMs do not “understand” prompts in any human sense but responds probabilistically [15]. The model processes the seed text statistically, predicting what might follow based on patterns in its training data. The output is not a continuation in the traditional sense but is closer to a productive distortion shaped by the model’s architecture, temperature settings, and system prompt, among other parameters. This distortion, I argue, is not unlike the distortion of the *Data Epics*, where the initial material (here, text; for the *Data Epics*, data) becomes something like a terrain of inquiry, encouraging a different reading (a re-reading) of both the initial material and the technical operations that transformed it. What emerges from this is a kind of double exposure in which more appears in a less defined way: more text, but blurred by both the embodied technology of automatic writing and the remixing of machine generated text. It is the work of trying to discern the shapes within the texts that makes reading them engrossing. It is, in other words, interpretation that makes the Automated Writing exercise powerful.

The Automated Writing exercise is perhaps the most literal enactment of hermeneutic engineering, in that it invites the user not to finish the text, but to continue the conversation. The reconfiguration does not happen so much at the system level (as with *Imprimer*) or even at the representation level (as with the *Data Epics*) but at the interaction level.

Performativity and Interpretation

The three projects presented in this dissertation—*Imprimer*, *Data Epics*, and the Automated Writing Exercise—each demonstrate how interpretation is materially enacted. In different ways, they illustrate how engagement with technical systems is never purely functional or representational, but can be improvisational, situated, and world-making. These forms of material interpretation are also, crucially, forms of participation. They show that to participate in the technological landscape is not only to use systems, but to

engage with them interpretatively—extending them, reshaping their operations, effects, and meanings through material practice. To develop this idea, I now turn to the work of media theorist Johanna Drucker, whose theory of interpretation as a performative and probabilistic process, that is as a process where possibilities are enacted in practice, sheds some light on how meaning emerges from use.

Drucker departs from traditional (what she calls objectivist) accounts of information and representation. In her essay “Performative Materiality and Interpretive Interface,” she argues that “no document or interface is ever entirely self-evident or objectively legible.” Rather, all artifacts, including digital ones, are “performative,” meaning they enact meaning through their structure, design, and the circumstances of their encounter. Artifacts come into being through acts of reading, manipulation, and engagement. Interpretation, in Drucker’s view, is not an operation on a stable object but an event that enacts the object’s intelligibility in a particular moment, for a particular reader, in a particular context. Drucker’s perspective is of course informed by her knowledge of the history of print and her material practice as a book artist [44]. It comes as no surprise then that Drucker challenges the notion of interfaces as transparent windows onto content—the impact of typography, layout, and paratextual information have on the reception of a text is an important lesson from the last information revolution we need to carry into the next.

Perhaps. The attempt to theorize materiality remains locked into a peculiar straight-jacketed literalism, I suggest, characterized by gestures towards and rhetoric about the need to engage with matter, but little actual skill in the undertaking. Inventories, lists, descriptive passages, the analysis of—what? Language and meter, prosody and composition, writing technique are on display again as if noticing the form of expression were a rare novelty rather than the baseline starting point for any interpretation it should be. Sometimes a bit of descriptive bibliographical information even appears in rare and more ambitious cases among those willing to dip into the archives inaccessible at their desktops and requiring still, in these lazy days, a visit to the special collections room and its rusty treasures. Materiality in the eager terms of its new devotees consists largely of a language of thick description, attention to physical details and identification of the manufacture of paper, style of type, or cost of binding.³ All this characterization is pressed into an indexical taxonomy through which these material clues track into the rich field of conditions of social production and historical traditions. All this is good, as far as it goes, and much to be preferred to the alternative—the habit of ignoring material instantiation of text or images if it were an act of intellectual immodesty to look at the way works are composed and made. The celebration of *transparency*, in which physicality

The first gestalt principle, emergence, or putting together, shows the need to differentiate figure and ground, see the coherent pattern among stimuli, make the first decisions about what belongs with what. Such cues as we rely on now, not always a feature of textual practice. Time was when no word space was used and none seemed to be required. But we can't navigate without it any more, lost in the thicket of those lines of text.

Figure 6.2. An excerpt from Drucker’s *Entity to Event: From Literal, Mechanistic Materiality to Probabilistic Materiality* [41]. To illustrate her point on the effect of media over message, Drucker writes a portion of the article without the usual letter spacing modern readers are used to.

Drucker calls instead for an interpretive interface, which would reveal its own framing, its own materiality—and by extension, invite interpretative engagement. In this sense, Drucker echoes and extends Citton’s emphasis on reconfiguration. But whereas Citton focuses on the symbolic and narrative dimensions of interpretation, Drucker emphasizes the procedural and embodied ones. Interpretation, for Drucker, is a situated performance in which tools, bodies, and contexts converge to bring a particular meaning into being.

She writes: “Interpretation does not reside in the output alone, but in the entire event of use” [41]. The interface, the user, and the system form a temporary alignment—a configuration—that is always provisional and potentially unstable. This performative and probabilistic account of interpretation is especially relevant in computational contexts. Traditional models of information assume a one-to-one correspondence between data and representation, as in data graphs [45]. But Drucker insists that meaning in digital systems is probabilistic: it emerges through patterns, inferences, and approximations, not certainties. This model of interpretation is about staging possible worlds, and seeing each act of reading as an opportunity to do so. This aligns with the project of hermeneutic engineering by suggesting the value of cultivating interpretative possibilities through and with tools.

To conclude

What do practices of digital fabrication, data storytelling, and algorithmic composition make visible about the possibilities of interpretation, and what are the consequences for the design of computational systems for epistemic practices and imaginative life? I hope the previous sections and chapters have made clear that interpretation is not a quaint literary exercise but an ontological condition of knowledge itself. From this perspective, it becomes possible to think computational engagement as the always-contingent staging of potential meanings and value. The goal here is to foreground how forms of representation are themselves co-produced through situated practices of reading, making, and re-making. In this final section I’d like to recast the three projects discussed in this dissertation as sites of material participation in Marres’s sense, and show how hermeneutic engineering can be extended, like any tool, for further interventions.

In Chapter 5, I mentioned three forms of legibility: material legibility, algorithmic legibility, and interpretive legibility, to differentiate between different levels of engagement when writing with transformers. But these forms of legibility are, in fact, present when interacting with computational artifacts more generally. For instance, with *Imprimer*, algorithmic legibility expressed itself in the form of toggle switches that could reveal the programs that generated toolpaths and controlled the CNC milling machine; in the *Data Epics*, the legibility of the data was constructed through the processes of interpretation and investigation of the home dwellers and writers. In the *Automated Writing Exercise*, the tension between human “illegibility” (the stream of consciousness writing) and machine readability created new interpretive possibilities, of both the human text and of algorithmic processes. Participants of the exercise did not probe the model’s architecture but they reflected on the capabilities and limitations of the tools by prompting it with illegible text. This subtle shift indicates that maintaining spaces of illegibility is crucial for open systems; for systems to be interpreted rather than used for “faster” outputs. The *Automated Writing Exercise*, just like the *Data Epics*, and *Imprimer*, make the case for maintaining “unreadable” spaces in encounters with computational artifacts—and to create spaces to interpret them.

Bibliography

- [1] Sara Ahmed. *Queer Phenomenology: Orientations, Objects, Others*. Durham: Duke University Press, 2006.
- [2] Anni Albers. *Anni Albers: Selected Writings on Design*. Wesleyan University Press, Apr. 2001.
- [3] Anni Albers. *Notebook 1970–1980*. David Zwirner Books, 2017. URL: <https://www.davidzwirner.com/collect/anni-albers-notebook-19701980-book>.
- [4] Roland Allen. *The Notebook: A History of Thinking on Paper*. Windsor, Ontario: Profile Books, 2023.
- [5] Morgan G. Ames. “Hackers, Computers, and Cooperation: A Critical History of Logo and Constructionist Learning”. In: *Proc. ACM Hum.-Comput. Interact.* 2.CSCW (Nov. 2018), 18:1–18:19. DOI: [10.1145/3274287](https://doi.org/10.1145/3274287).
- [6] Morgan G. Ames et al. “Making cultures: empowerment, participation, and democracy - or not?” In: *CHI '14 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '14. Toronto, Ontario, Canada: Association for Computing Machinery, 2014, pp. 1087–1092. DOI: [10.1145/2559206.2579405](https://doi.org/10.1145/2559206.2579405). URL: <https://doi.org/10.1145/2559206.2579405>.
- [7] Sonja Anderson. *ChatGPT Helped Write This Award-Winning Japanese Novel*. URL: <https://www.smithsonianmag.com/smart-news/this-award-winning-japanese-novel-was-written-partly-by-chatgpt-180983641/>.
- [8] Robert McNeel and Associates. *Rhinoceros 3D*. URL: <https://www.rhino3d.com/en/napa/>.
- [9] *Banter | Experiments with Google*. URL: <https://experiments.withgoogle.com/banter-bot>.
- [10] Karen Barad. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. English. Second Printing edition. Durham: Duke University Press Books, 2007.
- [11] Jeffrey Bardzell and Shaowen Bardzell. “Humanistic HCI”. In: *Synthesis Lectures on Human-Centered Informatics* 8.4 (2015), pp. 1–185. ISSN: 1946-7680. DOI: [10.2200/S00664ED1V01Y201508HCI031](https://doi.org/10.2200/S00664ED1V01Y201508HCI031).
- [12] Gabrielle Benabdallah. “Sybil: A Divinatory Home Device”. In: *Companion Publication of the 2020 ACM Designing Interactive Systems Conference*. DIS' 20 Companion. Eindhoven, Netherlands: Association for Computing Machinery, 2020, pp. 275–279. DOI: [10.1145/3393914.3395857](https://doi.org/10.1145/3393914.3395857). URL: <https://doi.org/10.1145/3393914.3395857>.

- [13] Gabrielle Benabdallah and Nadya Peek. “Technical Mentality: Principles for HCI Research and Practice”. In: *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*. CHI ’24. Honolulu, HI, USA: Association for Computing Machinery, 2024. DOI: [10.1145/3613904.3642720](https://doi.org/10.1145/3613904.3642720). URL: <https://doi.org/10.1145/3613904.3642720>.
- [14] Gabrielle Benabdallah et al. “Remote Learners, Home Makers: How Digital Fabrication Was Taught Online During a Pandemic”. In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. CHI ’21. Yokohama, Japan: Association for Computing Machinery, 2021. DOI: [10.1145/3411764.3445450](https://doi.org/10.1145/3411764.3445450). URL: <https://doi.org/10.1145/3411764.3445450>.
- [15] Emily M. Bender and Alexander Koller. “Climbing towards NLU: On Meaning, Form, and Understanding in the Age of Data”. In: *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*. Online: Association for Computational Linguistics, 2020, pp. 5185–5198. DOI: [10.18653/v1/2020.acl-main.463](https://doi.org/10.18653/v1/2020.acl-main.463). URL: <https://www.aclweb.org/anthology/2020.acl-main.463>.
- [16] Jane Bennett. *Vibrant Matter: A Political Ecology of Things*. English. unknown edition. Durham: Duke University Press Books, Jan. 2010.
- [17] E. L. Bishop. “Toward the Far Side of Language: Virginia Woolf’s The Voyage Out”. In: *Twentieth Century Literature* 27.4 (1981), pp. 343–361. ISSN: 0041-462X. DOI: [10.2307/441173](https://doi.org/10.2307/441173).
- [18] Julian Bleeker. “Design Fiction: A Short Essay on Design, Science, Fact and Fiction”. In: *Near Future Laboratory March* (2009). DOI: <https://doi.org/10.1145/1516016.1516021>.
- [19] Patricia Cain. *Drawing: The Enactive Evolution of the Practitioner*. English. Bristol: Intellect Ltd, 2011.
- [20] Noel Carroll. *On Criticism*. English. New York: Routledge, 2009.
- [21] Roger Chartier. *Forms and Meanings*. University of Pennsylvania Press, 1995. URL: <https://www.pennpress.org/9780812215465/forms-and-meanings/>.
- [22] Roger Chartier. *L’ordre des livres*. S.l.: Albin Michel, 1996.
- [23] Roger Chartier and Nigel Beale. *Roger Chartier on the Study of Book History and its Giants*. Nov. 2020. URL: <https://www.youtube.com/watch?v=e7uKji50iZ4>.
- [24] Kandice Chuh. *The Difference Aesthetics Makes: On the Humanities “After Man”*. URL: <https://www.amazon.com/Difference-Aesthetics-Makes-Humanities-After-ebook/dp/B07NKQ9WSW>.
- [25] Wendy Hui Kyong Chun. *Programmed Visions: Software and Memory*. URL: <https://direct.mit.edu/books/oa-monograph/3341/Programmed-VisionsSoftware-and-Memory>.
- [26] Sougwen Chung. *Drawing Operations*. URL: <https://sougwen.com/project/drawingoperations-memory>.
- [27] Yves Citton. *L’avenir des humanités*. La Découverte, 2010.
- [28] Yves Citton. *Lire, interpréter, actualiser*. Paris: Editions Amsterdam/Multitudes, 2017.

- [29] Yves Citton. *Médiarchie*. Paris: Seuil, 2017.
- [30] Yves Citton. *Pour une écologie de l'attention*. Seuil, 2014.
- [31] Lucille Clifton and Michael S. Glaser. “I’d like Not to Be a Stranger in the World: A Conversation/Interview with Lucille Clifton”. In: *The Antioch Review* 58.3 (2000), pp. 310–328. ISSN: 00035769. URL: <http://www.jstor.org/stable/4614023> (visited on 09/14/2025).
- [32] Catherine D’Ignazio and Lauren F. Klein. *Data Feminism*. Cambridge, Massachusetts: The MIT Press, Mar. 2020.
- [33] *D3: Data Driven Documents*. URL: <http://vis.stanford.edu/papers/d3>.
- [34] Lorraine Daston and Peter L. Galison. *Objectivity*. English. New York, NY: Zone Books, 2010.
- [35] *Data & Society’s Digital Doppelgangers Workshop*. URL: <https://datasociety.net/library/digital-doppelgangers/>.
- [36] René Descartes. *Règles pour la direction de l’esprit*. Vrin, 1997. URL: <https://www.vrin.fr/livre/9782711601820/regles-pour-la-direction-de-lesprit>.
- [37] Audrey Desjardins, Gabrielle Benabdallah, and Maya A. Kaneko. “Un/Making Data Imaginaries: The Data Epics”. In: *ACM Trans. Comput.-Hum. Interact.* 31.6 (Dec. 2024). ISSN: 1073-0516. DOI: [10.1145/3685269](https://doi.org/10.1145/3685269). URL: <https://doi.org/10.1145/3685269>.
- [38] Audrey Desjardins and Heidi R. Biggs. “Data Epics: Embarking on Literary Journeys of Home Internet of Things Data”. In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. CHI ’21. New York, NY, USA: Association for Computing Machinery, May 2021, pp. 1–17. DOI: [10.1145/3411764.3445241](https://doi.org/10.1145/3411764.3445241). URL: <https://doi.org/10.1145/3411764.3445241>.
- [39] Audrey Desjardins, Afroditi Psarra, and Bonnie A. Whiting. “Voices and Voids: Subverting Voice Assistant Systems through Performative Experiments”. In: *Proceedings of the 13th Conference on Creativity and Cognition*. C&C ’21. Virtual Event, Italy: Association for Computing Machinery, 2021. DOI: [10.1145/3450741.3466807](https://doi.org/10.1145/3450741.3466807). URL: <https://doi.org/10.1145/3450741.3466807>.
- [40] François Di Dio. “Une physique de la poésie”. fr. In: *Le Monde* (1971). URL: https://www.lemonde.fr/archives/article/1971/09/03/une-physique-de-la-poesie_2447175_1819218.html.
- [41] Johanna Drucker. “Entity to Event: From Literal, Mechanistic Materiality to Probabilistic Materiality”. In: *Parallax* 15.4 (Oct. 2009), pp. 7–17. DOI: <https://doi.org/10.1080/13534640903208834>.
- [42] Johanna Drucker. *Graphesis: Visual Forms of Knowledge Production*. English. Cambridge, Massachusetts: Harvard University Press, 2014.
- [43] Johanna Drucker. “Performative Materiality and Theoretical Approaches to Interface”. In: *Digital Humanities Quarterly* 007.1 (2013). ISSN: 1938-4122.
- [44] Johanna Drucker. *The Century of Artists’ Books*. English. New York City: Granary Books, 1995.

- [45] Johanna Drucker. *Visualization and Interpretation: Humanistic Approaches to Display*. English. Cambridge, Massachusetts: The MIT Press, Nov. 2020.
- [46] Elizabeth L. Eisenstein. *The Printing Revolution in Early Modern Europe*. English. 2nd edition. Cambridge University Press, Mar. 2012.
- [47] Foundation Fab. *FabLabs*. URL: <https://www.fablabs.io/>.
- [48] Michel Foucault. *Les mots et les choses*. Paris: Gallimard, Jan. 1990.
- [49] Michel Foucault. *Technologies of the Self: A Seminar with Michel Foucault*. Ed. by Luther H. Martin, Huck Gutman, and Patrick H. Hutton. University of Massachusetts Press. URL: <https://www.umasspress.com/9780870235931/technologies-of-the-self/>.
- [50] Brian Gabriel. “History of Writing Technologies”. In: *Handbook of Research on Writing*. Routledge, 2007.
- [51] Serge Gainsbourg and Brigitte Bardot. *Bonnie and Clyde*. Fontana/Phillips, 1967.
- [52] Alma García. *All That Rises*. English. Tucson: University of Arizona Press, 2023.
- [53] Neil Gershenfeld. *Fab: The Coming Revolution on Your Desktop—from Personal Computers to Personal Fabrication*. English. New York: Basic Books, 2007.
- [54] Lisa Gitelman. *Raw Data is an Oxymoron*. MIT Press, 2013. URL: <https://direct.mit.edu/books/edited-volume/3992/Raw-Data-Is-an-Oxymoron>.
- [55] *GPT4All*. URL: <https://www.nomic.ai/gpt4all>.
- [56] Victor A. Grauer. “Toward a unified theory of the arts”. In: *Semiotica* 94 (3-4 Jan. 1993). URL: <https://www.degruyterbrill.com/document/doi/10.1515/semi.1993.94.3-4.233/html?srsltid=AfmB0ooGBZTi0OSRaXiQA3p9P8cKegmJoaAu0xnFQW0q6EXvZR>.
- [57] David C. Greetham. *Textual Scholarship: An Introduction*. English. New York: Routledge, 1994.
- [58] W. W. Greg. “The Rationale of Copy-Text”. In: *Studies in Bibliography* 3 (1950), pp. 19–36. ISSN: 0081-7600.
- [59] Jean Grondin. *L’Universalité de l’herméneutique*. Paris: Presses Universitaires de France - PUF, 1993.
- [60] Donna Haraway. “Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective”. In: *Feminist Studies* 14.3 (1988), pp. 575–599. ISSN: 0046-3663. DOI: [10.2307/3178066](https://doi.org/10.2307/3178066).
- [61] Eric A. Havelock. *Preface to Plato*. English. Revised edition. Cambridge, Mass.: Belknap Press: An Imprint of Harvard University Press, Jan. 1963.
- [62] N. Katherine Hayles. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago, IL: University of Chicago Press, Feb. 1999. URL: <https://press.uchicago.edu/ucp/books/book/chicago/H/bo3769963.html>.
- [63] N. Katherine Hayles and Jessica Pressman, eds. *Comparative Textual Media: Transforming the Humanities in the Postprint Era*. University of Minnesota Press, 2013. URL: <https://www.upress.umn.edu/9780816680047/comparative-textual-media/>.

- [64] Clarisse Herrenschmidt. *Les trois écritures: Langue, nombre, code*. Paris, France: Gallimard, 2007.
- [65] Mare Hirsch et al. “Nothing Like Compilation: How Professional Digital Fabrication Workflows Go Beyond Extruding, Milling, and Machines”. In: *ACM Trans. Comput.-Hum. Interact.* 31.1 (Nov. 2023), 13:1–13:45. ISSN: 1073-0516. DOI: [10.1145/3609328](https://doi.org/10.1145/3609328).
- [66] Sun-ha Hong. *Technologies of Speculation: The Limits of Knowledge in a Data-Driven Society*. English. NYU Press, 2020.
- [67] Noura Howell et al. “Emotional Biosensing: Exploring Critical Alternatives”. In: *Proc. ACM Hum.-Comput. Interact.* 2.CSCW (Nov. 2018). DOI: [10.1145/3274338](https://doi.org/10.1145/3274338). URL: <https://doi.org/10.1145/3274338>.
- [68] Ivan Illich. *Tools for Conviviality*. English. London: Marion Boyars, 2009.
- [69] Sarah Inman and David Ribes. “Beautiful Seams”: Strategic Revelations and Concealments”. In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. New York, NY, USA: Association for Computing Machinery, May 2019, pp. 1–14. DOI: [10.1145/3290605.3300508](https://doi.org/10.1145/3290605.3300508). URL: <http://doi.org/10.1145/3290605.3300508> (visited on 11/24/2020).
- [70] Wolfgang Iser. *The Act of Reading: A Theory of Aesthetic Response*. English. Baltimore: Johns Hopkins University Press, 1994.
- [71] Kazuo Ishiguro. *Klara and the Sun: A GMA Book Club Pick*. English. New York: Knopf, 2021.
- [72] Sheila Jasanoff and Sang-Hyun Kim, eds. *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*. Chicago, IL: University of Chicago Press, 2015. URL: <https://press.uchicago.edu/ucp/books/book/chicago/D/bo20836025.html>.
- [73] Adrian Johns. *The Nature of the Book: Print and Knowledge in the Making*. Chicago, IL: University of Chicago Press, May 2000. URL: <https://press.uchicago.edu/ucp/books/book/chicago/N/bo3645773.html>.
- [74] Bettina Judd. “Glossolalia”. In: *Black Bodies and Transhuman Realities: Scientifically Modifying the Black Body in Posthuman Literature and Culture*. Ed. by Melvin G. Hill. Lexington Books, 2019.
- [75] Project Jupyter. *JupyterLab: the next generation of the Jupyter Notebook*. Aug. 2017. URL: <https://blog.jupyter.org/jupyterlab-the-next-generation-of-the-jupyter-notebook-5c949dabea3>.
- [76] Abderrahman M Khalaf et al. “The Impact of Social Media on the Mental Health of Adolescents and Young Adults: A Systematic Review”. In: *Cureus* 15.8 (), e42990. ISSN: 2168-8184. DOI: [10.7759/cureus.42990](https://doi.org/10.7759/cureus.42990).
- [77] Adam King. *InferKit*. URL: <https://inferkit.com/>.
- [78] Matthew G. Kirschenbaum. *Mechanisms: New Media and the Forensic Imagination*. Cambridge, MA, USA: MIT Press, Jan. 2012.
- [79] Alison Knowles. *House of Dust*. URL: <https://archive.centerforthehumanities.org/james-gallery/exhibitions/house-of-dust>.

- [80] D. E. Knuth. “Literate Programming”. In: *The Computer Journal* 27.2 (Jan. 1984), pp. 97–111. ISSN: 0010-4620. DOI: [10.1093/comjnl/27.2.97](https://doi.org/10.1093/comjnl/27.2.97).
- [81] Jonathan Kramnick and Anahid Nersessian. “Form and Explanation”. In: *Critical Inquiry* 43.3 (Mar. 2017), pp. 650–669. ISSN: 0093-1896. DOI: [10.1086/691017](https://doi.org/10.1086/691017).
- [82] Pierre Kropotkine. “La conquête du pain”. fr. In: *Oeuvres*. Ed. by Martin Zemliak. Maspero/Stock, 1976.
- [83] Lara Kuykendall. *Review of "Anni Albers: Notebook 1970-1980"*. Vol. 39. 2018.
- [84] Monica Latham. “Exploring the Limits of Unreadability: Virginia Woolf ’s Melymbrosia and The Voyage Out”. In: *Modernism and Unreadability*. Ed. by Isabelle Alfandary and Axel Nesme. Horizons anglophones. Montpellier: Presses universitaires de la Méditerranée, 2011, pp. 199–216. DOI: [10.4000/books.pulm.13765](https://doi.org/10.4000/books.pulm.13765). URL: <https://books.openedition.org/pulm/13765>.
- [85] Bruno Latour. “Can We Get Our Materialism Back, Please?” In: *Isis* 98.1 (Mar. 2007), pp. 138–142. ISSN: 0021-1753. DOI: [10.1086/512837](https://doi.org/10.1086/512837).
- [86] Matthew L. Lee-Smith et al. “Data as a Material for Design: Alternative Narratives, Divergent Pathways, and Future Directions”. In: *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*. CHI EA ’23. Hamburg, Germany: Association for Computing Machinery, 2023. DOI: [10.1145/3544549.3573817](https://doi.org/10.1145/3544549.3573817). URL: <https://doi.org/10.1145/3544549.3573817>.
- [87] Pierre Lévy. *Les technologies de l’intelligence: l’avenir de la pensée à l’ère informatique*. fr. Seuil, 1993.
- [88] John Lewis. *Anatomy of printing: the influences of art and history on its design*. eng. London: Faber, 1970.
- [89] Jingyi Li et al. “Direct and Immediate Drawing with CNC Machines”. In: *Proceedings of the 1st Annual ACM Symposium on Computational Fabrication*. SCF ’17. New York, NY, USA: ACM, 2017, 11:1–11:2. DOI: [10.1145/3083157.3096344](https://doi.org/10.1145/3083157.3096344). URL: <http://doi.acm.org/10.1145/3083157.3096344> (visited on 01/11/2019).
- [90] Silvia Lindtner, Shaowen Bardzell, and Jeffrey Bardzell. “Reconstituting the Utopian Vision of Making: HCI After Technosolutionism”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. San Jose, California, USA: Association for Computing Machinery, 2016, pp. 1390–1402. DOI: [10.1145/2858036.2858506](https://doi.org/10.1145/2858036.2858506). URL: <https://doi.org/10.1145/2858036.2858506>.
- [91] Daniel Cardoso Llach. *Builders of the Vision*. Routledge, 2015.
- [92] Nicholas Logler. “Exploring Material Imaginaries: Action and Possibility in Everyday Artifacts”. PhD thesis. University of Washington, 2023.
- [93] Yanni Alexander Loukissas. *All Data Are Local: Thinking Critically in a Data-Driven Society*. Illustrated edition. Cambridge, Massachusetts: The MIT Press, Apr. 2019.
- [94] Marielle Macé. *Styles: Critique de nos formes de vie*. Paris: Gallimard, 2016.
- [95] Marina Magloire. *Spirit Writing, Body Problems: Lucille Clifton’s Faith*. 2022. URL: <https://scholarblogs.emory.edu/marbl/2022/07/13/spirit-writing-body-problems-lucille-cliftons-faith/>.

- [96] Marina Magloire. *The Spirit Writing of Lucille Clifton by Marina Magloire*. Oct. 2020. URL: <https://www.theparisreview.org/blog/2020/10/19/the-spirit-writing-of-lucille-clifton/>.
- [97] Bonnie Mak. *How the Page Matters*. English. Toronto: University of Toronto Press, 2011.
- [98] “Marginalized”. In: *Lapham’s Quarterly* 5.2 (2012). URL: <https://www.laphamsquarterly.org/communication/charts-graphs/marginalized>.
- [99] Noortje Marres. *Material Participation: Technology, the Environment and Everyday Publics 2nd edition by Marres, Noortje (2015) Paperback*. English. Palgrave Macmillan.
- [100] Ian McEwan. *Machines Like Me*. English. New York: Nan A. Talese, 2019.
- [101] Jerome J. McGann. *The Textual Condition*. English. Princeton, N.J: Princeton University Press, 1991.
- [102] Iain McGilchrist. *The Master and His Emissary: The Divided Brain and the Making of the Western World*. English. New Haven: Yale University Press, 2019.
- [103] D. F. McKenzie. *Bibliography and the Sociology of Texts*. Cambridge: Cambridge University Press, 1999. DOI: [10.1017/CB09780511483226](https://doi.org/10.1017/CB09780511483226). URL: <https://www.cambridge.org/core/books/bibliography-and-the-sociology-of-texts/CF5FE52FD90E0B79D8583FF675C4923D>.
- [104] Maurice Merleau-Ponty. *Phénoménologie de la perception*. Paris: Gallimard, 1976.
- [105] Nick Montfort. *World Clock*. Nov. 2013. URL: <https://nickm.com/post/2013/11/world-clock/>.
- [106] William Morris. *A Factory As It Might Be*. URL: <https://www.marxists.org/archive/morris/works/1884/justice/10fact1.htm>.
- [107] Ann Moss. *Printed Commonplace-Books and the Structuring of Renaissance Thought*. English. Oxford: New York: Clarendon Press, 1996.
- [108] John A. Naslund et al. “Social Media and Mental Health: Benefits, Risks, and Opportunities for Research and Practice”. In: *Journal of technology in behavioral science* 5.3 (2020), pp. 245–257. ISSN: 2366-5963. DOI: [10.1007/s41347-020-00134-x](https://doi.org/10.1007/s41347-020-00134-x).
- [109] *Natural Language Processing Dates Back to Kabbalist Mystics*. Oct. 2019. URL: <https://spectrum.ieee.org/natural-language-processing-dates-back-to-kabbalist-mystics>.
- [110] David Noble. *Forces of Production*. English. 1st edition. New Brunswick, N.J: Routledge, Mar. 2011.
- [111] David Noble. “Present Tense Technology: Part Three”. In: *Democracy Journal Archive* (1983), pp. 543–551.
- [112] Safiya Umoja Noble. *Algorithms of Oppression: How Search Engines Reinforce Racism*. English. Illustrated edition. New York: NYU Press, Feb. 2018.
- [113] *Observable HQ*. URL: <https://observablehq.com>.

- [114] *Once Upon a Lifetime | Experiments with Google*. URL: <https://experiments.withgoogle.com/once-upon-a-lifetime>.
- [115] Walter J. Ong. *Orality and Literacy*. English. 1st edition. London; New York: Routledge, Oct. 1982.
- [116] OpenProcessing. *OpenProcessing*. URL: <https://openprocessing.org/>.
- [117] Julie Park. “Line Making as Life Writing: Graphic Literacy and Design in Eighteenth-Century Commonplace Books”. In: *Eighteenth-Century Life* 48.1 (2024), pp. 72–91. ISSN: 1086-3192.
- [118] Allison Parrish. *Pincelate*. URL: <https://pincelate.readthedocs.io/en/latest/>.
- [119] Richard Parry. “Epistem and Techne”. In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta and Uri Nodelman. Winter 2024. Metaphysics Research Lab, Stanford University, 2024. URL: <https://plato.stanford.edu/archives/win2024/entries/episteme-techne/>.
- [120] Francis Ponge. *Le Parti pris des choses*. Paris: Belin Education, 1943.
- [121] Richard Powers. *The Overstory*. English. New York London: W. W. Norton & Company, 2019.
- [122] Jacques Rancière. *Le Partage du sensible: Esthétique et politique*. Paris: La Fabrique, 2000. URL: <https://www.amazon.com/Partage-sensible-Esth%C3%A9tique-politique/dp/2913372058>.
- [123] Matt Ratto. “Critical Making: Conceptual and Material Studies in Technology and Social Life”. In: *The Information Society* 27.4 (2011), pp. 252–260. ISSN: 0197-2243, 1087-6537. DOI: [10.1080/01972243.2011.583819](https://doi.org/10.1080/01972243.2011.583819).
- [124] Christophe Reig et al. “Les Effets de l’OuLiPo”. fr. In: (Dec. 2021). URL: <https://hal.science/hal-03551810>.
- [125] Paul Ricoeur. *La Métaphore vive*. Paris: Seuil, 1994.
- [126] Daniela K. Rosner. *Critical Fabulations: Reworking the Methods and Margins of Design*. Design Thinking, Design Theory. Cambridge, MA, USA: MIT Press, 2018.
- [127] Adam Rule, Aurélien Tabard, and James D. Hollan. “Exploration and Explanation in Computational Notebooks”. In: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. CHI ’18. New York, NY, USA: Association for Computing Machinery, Apr. 2018, pp. 1–12. DOI: [10.1145/3173574.3173606](https://doi.org/10.1145/3173574.3173606). URL: <https://dl.acm.org/doi/10.1145/3173574.3173606>.
- [128] Jentery Sayers. *Making Things and Drawing Boundaries: Experiments in the Digital Humanities*. English. University of Minnesota Press, 2018. URL: <http://muse.jhu.edu/book/57411>.
- [129] Eric Schatzberg. *Technology: Critical History of a Concept*. Chicago, IL: University of Chicago Press, Nov. 2018. URL: <https://press.uchicago.edu/ucp/books/book/chicago/T/bo28911204.html>.
- [130] Donald A. Schon. *The Reflective Practitioner: How Professionals Think In Action*. English. 1st edition. New York: Basic Books, 1984.

- [131] Emilien Schultz. “Du laboratoire à Jupyter: La trajectoire d’un instrument logiciel libre de la science ouverte”. Nov. 2023. URL: <https://hal.science/hal-04316428>.
- [132] Janelle Shane. *AI Weirdness*. URL: <https://www.aiweirdness.com/>.
- [133] Viktor Shklovsky. “Art as Device”. In: *Viktor Shklovsky: A Reader*. Ed. by Alexandra Berflina. Bloomsbury Academic, 2016. URL: <https://www.bloomsbury.com/us/viktor-shklovsky-9781501310362/>.
- [134] Herbert A. Simon. *The Sciences of the Artificial*. Illustrated edition. Cambridge, Massachusetts: The MIT Press, Aug. 2019.
- [135] Gilbert Simondon. *Du mode d’existence des objets techniques*. Paris: Aubier, Oct. 2012.
- [136] Gilbert Simondon. *L’individuation à la lumière des notions de forme et d’information*. Grenoble: Editions Jérôme Millon, Nov. 2005.
- [137] Gilbert Simondon. *Sur la technique*. Paris: Presses Universitaires de France, Jan. 2014.
- [138] Robin Sloan. *Mr. Penumbra’s 24-Hour Bookstore*. English. New York: Picador, 2013.
- [139] C. P. P. Snow. *The Two Cultures*. English. Cambridge, U.K.; New York: Cambridge University Press, 2012.
- [140] Susan Sontag. *On Photography*. English. New York: Picador, 2010.
- [141] Hortense J. Spillers. “Mama’s Baby, Papa’s Maybe: An American Grammar Book”. In: *Diacritics* 17.2 (1987), pp. 65–81. ISSN: 0300-7162. DOI: [10.2307/464747](https://doi.org/10.2307/464747).
- [142] Luke Stark. *Come on Feel the Data (and Smell It)*. May 2014. URL: <https://www.theatlantic.com/technology/archive/2014/05/data-visceralization/370899/>.
- [143] George A. Stevenson. *Graphic Arts Encyclopedia*. English. McGraw-Hill.
- [144] Leo Graiden Stewart et al. “Drawing the Lines of Contention: Networked Frame Contests Within BlackLivesMatter Discourse”. In: *Proc. ACM Hum.-Comput. Interact.* 1.CSCW (Dec. 2017). DOI: [10.1145/3134920](https://doi.org/10.1145/3134920). URL: <https://doi.org/10.1145/3134920>.
- [145] Bernard Stiegler and Camille Riquier. “Critique de la raison impure: Entretien avec Bernard Stiegler”. In: *Esprit* 433 (2017), pp. 118–129. ISSN: 0014-0759.
- [146] Allucquère Rosanne Stone. *The War of Desire and Technology at the Close of the Mechanical Age*. Cambridge, MA, USA: MIT Press, 1996.
- [147] Christopher Strachey. *Love letters*. URL: <https://www.gingerbeardman.com/loveletter/>.
- [148] The Grocery Studios. *Data Epics project event*. May 2022. URL: <https://thegrocerystudios.com/data-epics-project/>.
- [149] Lucy Suchman. “Configuration”. In: *Inventive Methods*. Routledge, 2012.

- [150] Charles Taylor. “Interpretation and the sciences of man”. In: *Philosophical Papers: Volume 2: Philosophy and the Human Sciences*. Vol. 2. Cambridge: Cambridge University Press, 1985, pp. 15–57. DOI: [10.1017/CB09781139173490.002](https://doi.org/10.1017/CB09781139173490.002). URL: <https://www.cambridge.org/core/books/philosophical-papers/interpretation-and-the-sciences-of-man/7D01DD62259048845EE15C6EDC77049D>.
- [151] High-Low Tech. URL: <https://highlowtech.org/>.
- [152] David Yi Tenen. *Plain Text: The Poetics of Computation*. Stanford University Press, 2017. URL: <https://www.sup.org/books/literary-studies-and-literature/plain-text>.
- [153] Studio Tilt. *Data Epics website*. URL: <https://dataepics.webflow.io/>.
- [154] Miles A. Tinker. “Experimental Studies on the Legibility of Print: An Annotated Bibliography”. In: *Reading Research Quarterly* 1.4 (1966), pp. 67–118. ISSN: 0034-0553.
- [155] Jasper Tran O’Leary, Gabrielle Benabdallah, and Nadya Peek. “Imprimer: Computational Notebooks for CNC Milling”. In: *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. CHI ’23. New York, NY, USA: Association for Computing Machinery, Apr. 2023, pp. 1–15. DOI: [10.1145/3544548.3581334](https://doi.org/10.1145/3544548.3581334). URL: <https://dl.acm.org/doi/10.1145/3544548.3581334>.
- [156] Vasiliki Tsaknaki et al. “Challenges and Opportunities for Designing with Biodata as Material”. In: *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*. NordiCHI ’20. Tallinn, Estonia: Association for Computing Machinery, 2020. DOI: [10.1145/3419249.3420063](https://doi.org/10.1145/3419249.3420063). URL: <https://doi.org/10.1145/3419249.3420063>.
- [157] Sherry Turkle, ed. *Evocative Objects: Things We Think With*. Cambridge, Mass: The MIT Press, 2007.
- [158] Hannah Twigg-Smith, Jasper Tran O’Leary, and Nadya Peek. “Tools, Tricks, and Hacks: Exploring Novel Digital Fabrication Workflows on #PlotterTwitter”. In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. CHI ’21. New York, NY, USA: Association for Computing Machinery, May 2021, pp. 1–15. DOI: [10.1145/3411764.3445653](https://doi.org/10.1145/3411764.3445653). URL: <http://doi.org/10.1145/3411764.3445653> (visited on 05/19/2021).
- [159] *Uuna Tek Website*. 2025. URL: <https://uunatek.com/>.
- [160] Francisco J. Varela, Evan T. Thompson, and Eleanor Rosch. *The Embodied Mind: Cognitive Science and Human Experience*. English. Cambridge, Mass.: Mit Pr, 1993.
- [161] Ashish Vaswani et al. “Attention Is All You Need”. In: *CoRR* abs/1706.03762 (2017). arXiv: [1706.03762](https://arxiv.org/abs/1706.03762). URL: <http://arxiv.org/abs/1706.03762>.
- [162] François-Xavier de Vaujany and Nathalie Mitev. “Introduction au tournant matériel en théories des organisations”. In: *Les théories des organisations*. Ed. by Economica. Economica, 2015. URL: <https://hal.science/hal-01215557>.
- [163] Thomas Vercruyssen. *La kairologie: Pour une poétique de la circonstance*. Genève: Droz, Feb. 2019.

-
- [164] Fabienne Verdier. *Fabienne Verdier's website*. URL: <https://fabienneverdier.com/>.
- [165] Inkscape Website. *Inkscape - Draw Freely. | Inkscape*. URL: <https://inkscape.org/>.
- [166] Karl D.D. Willis et al. “Interactive fabrication: new interfaces for digital fabrication”. In: *Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction*. TEI '11. Funchal, Portugal: Association for Computing Machinery, 2010, pp. 69–72. DOI: [10.1145/1935701.1935716](https://doi.org/10.1145/1935701.1935716). URL: <https://doi.org/10.1145/1935701.1935716>.
- [167] James Wood. “Kazuo Ishiguro Uses Artificial Intelligence to Reveal the Limits of Our Own”. In: *The New Yorker* (Mar. 2021). ISSN: 0028-792X. URL: <https://www.newyorker.com/magazine/2021/03/08/kazuo-ishiguro-uses-artificial-intelligence-to-reveal-the-limits-of-our-own>.
- [168] Virginia Woolf. *Melymbrosia*. San Francisco: Cleis Press, 2002.
- [169] Virginia Woolf. *The Voyage Out*. Penguin Random House, 2021.
- [170] Sylvia Wynter. “The Ceremony Must be Found: After Humanism”. In: *boundary 2* 12.3 (1984), p. 19. DOI: <https://doi.org/10.2307/302808>.

