

# Chapter 8. Making the World Scientifically Thinkable: Inscribing Experience Methodically and Its Cognitive Consequences

We experience through our senses often without words, numbers, or other semiotic representation or calculation.<sup>1</sup> To share our experiences, however, we use the limited channel of words and other semiotic relations, reducing what we sense and feel to the words and symbols available to us, within the context of the communicative moment, the people we communicate with, and our purposes. For our experiences, however, to be thought about more extensively, precisely, and reflectively—and particularly more scientifically—those experiences (including those gathered through measuring devices) must be inscribed in some semiotic way. This is equally the case for data created at a distance, from other people's experience, from instrumentation or other sources beyond our five senses. Thus, the transformation of experience, our own and others, into data, through methods we and our scientific communities consider appropriate, is an essential component of scientific thought, providing the evidentiary grist for our reasoning and potential contributions. Whatever the complex neurological happenings that occur within our skins and brains, when solving scientific problems, our internal processes depend on inscribed semiotic representations of external objects. The production of these semiotic inscriptions is further constrained and directed by the means of collection and inscription, as reflected on by methodological discussions. I explore these processes and implications for scientific thought through several examples in the following paragraphs.

## Communicative Fundamentals Inside and Outside the Skin Barrier

I am going to start off by being really basic, but I hope you will see the payoff in specific research issues by the time I am done. A core issue in understanding the relationship between language and the mind is the intertwined difference between the two distinct communicative systems on either side of the skin barrier. What we experience through our senses (that is, our sense organs) is then processed and responded to through our complex neural system, often without words, numbers, or other semiotic means.

---

1. An earlier version of this chapter was presented at the GEWISS conference, Vienna, Austria, September 10–15, 2023.

We can, however, report and share our observations, experiences, and sensations with others, using the words, numbers, and other semiotic means available to us within the context of the communicative moment, including who we are speaking with and for what purposes. Nonetheless, those signs are formulated through our internal neural system that directs our communicative organs (such as speech organs or fingers on a keyboard), and the signs are interpreted by others through their internal neurological processes.

What we (and our interlocutors) sense and then form into symbols, accordingly, activates additional or different processes internally than unsymbolized sense experiences, though internally they may be connected in some way. Words (learned from others) may direct our perceptions, thinking, and actions. Further, internally, at least some words may be consciously perceivable in subvocalized or nonvocalized ways. Words and other signs, however, may become transformed as they enter more deeply into less conscious parts of our neural system and attach to traces of other experiences, though these subterranean processes and the neural encodings are unclear. I personally find much merit in Lev Vygotsky's (1986) approach to internalization.

When we want to report or share our thoughts, perceptions, and experiences, neural impulses must then engage with the socially shared systems of words and other signs to be transmitted to others for them to interpret and attach meaning to. Vygotsky and his followers considered this as a process of externalization, though their proposals for this externalization process are less well developed than proposals for internalization (Bazerman, 2012). Oral speech production may be extremely rapid with only the briefest of conscious forethought and may even seem spontaneous with only subconscious formulating processes at play. For writing, however, these externalization processes may be more salient and reportable—because writing often has an extended semiprivate production process which affords greater reflection, conscious choice making, emendation, and drafting. Similarly, reading affords a slow process of interpretation, reexamination, and reflection, though in practice to a lesser extent than writing, because so much of reading becomes automated in childhood and processed subconsciously as people develop reading skills. We read many things rapidly without conscious problem-solving.

In contrast to most other texts which may rely heavily on individual subjective sense and emotional impulse, scientific and other scholarly writing is strongly accountable to the data initially gathered about the world by the researcher or colleagues. All data, whether qualitative or quantitative, whether observed directly or read from the digital output of a mechanical device, are already presented in some kind of symbolic form, even though subjective impressions, hunches, and intuitions may direct the researcher to examine certain data sources and use methods that will provide systematic evidence of those unarticulated impulses. As the title of Lisa Gitelman's (2013) edited collection announces: *Raw Data is an Oxymoron*. Further, the researcher, through prior training and reading in

the field's literature, will be experiencing the world and data through concepts, categories, and ideas previously developed within the scholarly area, even if the impulse is to contest some current ways of conceptualizing phenomena and theories. Of course, as the researcher attempts to make sense of the data and create potential contributions to the scholarly/scientific field, the data may enter into the subconscious/unconscious ponderings of the scholar and be transformed into some internal neurological form not recognizable in public semiotic means.

## Some Examples of Thought With Semiosis In and Semiosis Out

I am here not going to discuss the social processes by which such semiotic contributions enter into scholarly discussions, evaluations, and applications nor consequently the way data becomes evidence in academic arguments. I do that elsewhere. Here I am only framing the internal processes by the phrase “semiosis in and semiosis out” in order to point out the consequentiality of the semiosis for the problems being worked on inside the skin barrier with the goal of producing some kind of semiotic output for the scholarly discussion. I am going to give a couple of examples: first from others, then my own research, and finally my own experience. These may help make clearer what I am talking about.

First is a classic account from Bruno Latour and Steve Woolgar's (1979) *Laboratory Life* which portrayed a laboratory essentially as a factory that turns living mice into scientific papers with data and scientific arguments. Along the way, the mice are labelled and undergo controlled conditions and experiences before being sacrificed. Then their brains are harvested, centrifuged, and undergo chromatography, with components labelled, measured, and put in charts and tables. Those charts and tables then go to the front office where scientists make sense of the data and write papers to be sent out to journals. Latour and Woolgar called this a process of forgetting about the materiality of real mice in order to produce inscriptions—materiality in and semiotics out. Nonetheless, the labelling, maze running, animal sacrificing, brain extraction, centrifuges, chromatography tests, measurements, tables, analysis, and article drafting embody long histories of literature, argument over methods and findings, codification of knowledge, establishing concepts, etc. So semiosis is all around, into which specific materiality is introduced and experimented on and data is collected and analyzed about. The intentional, purposive inscription is part of a focused remembering (framed by prior inscriptions) of what is to be reasoned about and added to the semiotic universe. Semiosis in, materiality added, and semiosis out.

My next example, based on my own research (Bazerman, 1984), is from the notebooks and drafts of Arthur Holly Compton. The notebooks and drafts show how important data were for him and how carefully he thought about how they were produced. He was trying to confirm a shift, which he had presented in an earlier and well-known paper, from a classic electrodynamic explanation to a quantum

theory account of what was to become known as the Compton effect. The later article being developed in the notes and drafts I studied used the newly invented cloud chamber, whereby individual particle movements were made visible by condensation trails which were then photographed for measurement and analysis.

In his notebooks and drafts Compton grappled with the difficulty that he was not able to see the particles nor measure their energies directly; he could only see photographs of condensation trails and measure their angles of deflection after collision events (as cited in Bazerman, 1984). After eliminating some trial runs, he eliminated 19 of the remaining 33 plates, leaving only 14 to be measured and analyzed. The notebooks indicated that his criterion for selection was whether the photographs produced clear and distinct tracks that were not too crowded for measurement. That is, the images of the condensation trails inscribed on photographic plates were evaluated particularly from the perspective of whether they could be accurately measured and turned from graphic data into numerical. When he calculated corrections for distortion in the photographic recording, he was careful to offer specific justification and measurements for the calculation—that is he retained the integrity of the fourteen plates while factoring in distorting factors on the photographic equipment. Further, when Compton wrote up his analysis using words, he made a number of types of corrections to precisely characterize the data and their relation to the theoretical explanation. One of the most interesting characterizations was clarifying whether at each point he was referring to photographic images (visualized through instrumental means), tracks (measured), particles (imputed), or quanta (hypothesized).

In these and other aspects of Compton's emergent statement, I found him holding himself accountable to his collected data and the conditions of their collection at the same time as characterizing the kinds of calculation and reasoning used at each point in his argument. Here the imputed real-world objects (the particles and energy quanta) were not directly perceivable by him but only accessible by experimental devices and instrumentation, so he had only semiotic data to work with—the signs of things unseen. His thinking was entirely semiosis in and semiosis out, though interposing materiality from an experiment. The experimental results, however, are only seen through signs. Yet he was very careful to provide the best semiotic representation of the data that he could. Of course, this synopsis doesn't actually get at what went on in Compton's neurological processing inside the skin barrier, but it does reflect his orientation in producing the work and dealing with the emerging representations of the article.

More recently I did three studies of undergraduate students working with data to see how the collection or analysis of the data would affect their reasoning. In a study of mechanical engineers engaged in a final year team project, which required a series of interim reports culminating in a final report, my co-author and I found that the students collected data from different sources for each report, directed by the requirements of each (Bazerman & Self, 2017). The first report called for a general search of the literature on the problem the students proposed

to solve. Then, reporting on a site visit required them to observe a clinic and interview clinic workers and its clients to determine needs and capabilities. A specific design proposal then relied on information about materials and alternative devices available in a variety of technical sources. A report on fabricating a prototype and laboratory testing followed; the final report included field testing. The data the students collected at each point helped them to solve each level of problem according to project requirements and move on to the next step. The data and analysis of each step then became embedded as a kind of textual boiler plate in consequent reports, which meant the data and analysis had become a stabilized and taken for granted part of their thinking, as they then solved subsequent problems. So again, while we did not have access what went on inside the neural system of each student, we could track the semiotic elements that went into their reasoning and calculations, which then served as assumptions for the next iteration of collection and reasoning represented in the next report.

Another study involved three fourth-year political science students doing honors research projects. The study found that the greater experience and understanding students had of research methods and methodology, the greater flexibility and control they had in being able to design their research and the greater understanding they had of the character and meaning of the data they were able to collect (Bazerman, 2019). Consequently, the students' understanding of methodology and application of method affected the quality of their final papers. All spent a lot of time thinking about their problems, but those with greater methodological sophistication did so far more productively than others. They were able to formulate and think through problems inside the skin barrier (as they confirmed in interviews) and then externalize solutions in the final semiotic object of the research thesis.

A third study involved linguistics students in an undergraduate sociolinguistics course and found that students working with data changed their perceptions and orientations towards language they encountered in their consequent assignments and in their daily life (Fahler & Bazerman, 2019). This changed orientation towards language influenced the students' perception of others and their relations with them.

In all these five examples, experience of the world and its materiality was mediated through the semiotic means by which the world was represented. At some points in these examples we can see the semiotic means providing grist for internal processing, and in all cases we can see the semiotic means directing, limiting, and transforming what could be shared, sedimenting experience and materiality in the terms made available by semiotic resources.

## Getting Inside With Some Personal Examples

I end with three introspective anecdotes of my experience as a younger academic writer, which permit me a bit to report introspectively and autobiographically on

what happens inside the skin barrier, as framed by the semiotic situation. I have strong memories of these remarkable events, though filtered through time and personal bias. They each indicate how highly salient internal experiences involving neurocognitive processes can be set up and enabled by semiosis in and can result in creative semiosis out.

First, thirty-five years ago, I started working on a book to follow on *Shaping Written Knowledge* (Bazerman, 1988), which was to be about the discursive history leading to our modern understanding of electricity. In that earlier book and other writings, I had been developing a set of concepts about genre and activity systems, drawing on multidisciplinary literature I had been reading in interaction with the materials I had been researching. For the new book I had already written a few chapters about earlier moments in the history of electricity. My plan for the new book was to have a last chapter devoted to Thomas Edison's central light and power. I had read about Edison and the emergence of his system, but I had not yet looked at any of the primary Edison documents. My first morning at the Edison archives, after examining the finder volume, I requested a folder of letters Edison received in the days immediately following a newspaper interview where he announced that he had solved the problem of incandescent lighting, although he really hadn't. Nonetheless, many people took him at his word and they began to write to him. All of them wrote in standard letter format with ordinary personal information and requests. They were just letters. I started taking analytical notes as I read them, and I almost immediately saw in each letter the edge of a documentary activity system that motivated the writers and defined their request—and in a sense the framework within which they placed their hopes on the charismatic Edison. For some it was the political system of local governance, for others it was technical expertise and the hope of employment, for some it was equity investment opportunity, and for a widow on a fixed income it was a threat to her holdings in gas stocks.

Within an hour a vision emerged within me of the book that was to become *The Languages of Edison's Light* (Bazerman, 1999). Over lunch I excitedly started to outline the book, which was to guide my thought, attention, imagination, and examination of documents for the next ten years. This vision guided my dreams and lesser moments of inspiration, as well as drove determination and persistence through ten years of often tedious work. We could say that this was just another example that fortune and inspiration come to the prepared mind—but if we dig deeper into it, we can see the theories, information, and inquiry impulses that informed my perceptions of those ordinary looking letters in front of me. I had been articulating these ideas and describing the data in publications, speeches, and private notes for years. Consequently, the activity systems I saw in those letters led me to examine other files that would flesh out the thoughts and become grist for analysis and evidence. Semiosis in—lots of semiosis in. A book of semiosis out, and in the middle a lot of neurological events—emotional, cognitive, calculative—along with the examination of a lot of data, most in the

semiotic form of the Edison papers, though I did visit his worksites and examine some of his devices.

A few years before that, after I had done some genre histories and other studies of scientific writing, I took to heart some criticisms made by historians that I needed to look at how specific actors and events shaped history. So I started to look at the role of individuals in the founding of the Royal Society and its journal, *Philosophical Transactions*. On a trip to London, I visited the archives of the Royal Society, and I started to see the roles of members transforming and proliferating as institutional changes occurred and as submissions to the journals started to undergo regularized reviewing procedures. At the same time, I was reading sociological theory about roles and role conflicts. I began putting these parts together for a promised lecture on the effect of journal publication on the emerging social structure of science. As I began thinking about the multiple roles early scientists took on around early journals—society members, audiences, writers, reviewers, editors, colleagues, recipients of reviews, I began seeing how role conflicts emerged. When I put this together with Robert K. Merton's (1973) norms of science, the pieces started to click into place as I saw how the norms of science were acting as ways to mediate the new conflicting roles that were emerging around journal publication and emerging scientific organizations. Realizations started to fall in place over a number of days, perhaps a week, mostly as I did a daily swim. I had a series of light bulbs going off in my head every day as the parts made sense. When I got home, I started writing notes to myself and drafting parts of a chapter, setting myself up for new insights the next day. So it was a remarkable neurocognitive experience, phenomenologically memorable. But it was set up by lots of semiosis in, including a lot of language data (after all, my data were all documents) but also theoretical and conceptual data from prior studies. The emotionally charged events going on in my head as pieces clicked into place evoked language fragments from the theories I was reading, but also surprised expressions of insight: "Oh, this fits with that..." "Oh, that's why..." Further, there was the immediate exigency of the upcoming lecture accompanied by the desire to tell a story that might be more respected by historians while showing genre theory was a kind of institutional history that influenced social relations. This talk was to be incorporated into *Shaping Written Knowledge*. Again, semiosis in, semiosis out, with lots of neurocognitive sense making and problem solving in the middle, some of which was surfacing in semiotic form as I became more conscious of what I was feeling internally. Underneath that all, I was having lots of geometric imagery in mind and lots of dreams about making or missing train and plane connections, as I often have when writing.

Finally, here is perhaps the most striking of my writing experiences. During my undergraduate years, I had carried from my troubled family life a lot of personally unresolved and poorly articulated (and at that time some totally unarticulated) problems, experienced at unconscious, semiconscious, and affective levels. I was using my undergraduate papers, particularly in humanities subjects, as ways of trying to figure out many things about my life, even while overtly

addressing the assignments and material of the courses. This process of undergraduates using assignments for self-articulation and personal problem solving has been noted by a number of scholars for many years now—perhaps most aptly here in Anne J. Herrington and Martha Curtis’s (2000) *Persons in Process*. The most memorable of those experiences I recognized as remarkable at the time, but I only partly understood its meaning and personal importance then. In my third year of university in the fall of 1965 I was taking a world drama course from an inspiring young teacher of dramatic literature, Scott McMillin. After a series of assigned papers throughout the term that required interpreting various individual plays, our final assignment was to choose a four-play season for a repertoire company and provide a rationale for bringing those plays together. This essay produced many important insights for my personal self-understanding and direction, perhaps even being a turning point in a crisis, but the paper itself did not reach beyond a discussion of the plays. What is most significant here is the psychological phenomenological process I went through in writing this paper. Here is how I described it in my writing autobiography:

I remember the process of writing this paper as almost in a trance. I became exhausted after writing each part, falling asleep in the middle of the day, waking only for meals and writing another paragraph or two, then immediately falling back into sleep for more hours, then dragging myself up, writing a bit more, then falling back into sleep. This went on for several days, as though I were in a deep and exhausting meditation, floating in and out of a dream, but a dream so drugged I had no memory except the impulse to take the next step of the journey. This was the kind of experience vatic priests must have had when they felt the words come from elsewhere but channeled through them, knocking them down, knocking them out.

...

I awoke from the dream with a new direction and new sense of self. Twenty years later James Pennebaker was to start the research that led him to understand the powerful effect of trauma writing, which he was eventually to attribute in part to allowing the writer to confront distressing events by building a coherent story one could live with (see Pennebaker & Chung, 2007). Around 2000 when a graduate student introduced me to Pennebaker’s work establishing that trauma writing could even improve our immune system, blood counts, health outcomes and other biological markers, I immediately recognized from my experiences the implication that writing could reach down into the core organization of ourselves and anxiety systems, and



thus could influence the way we perceived and responded to the world around us. This paper for an undergraduate course brought together a deep and comprehensive story about the world and my life which I had been struggling with since high school. It crystallized an important reorganization in my life. (Bazerman, 2023, pp. 88–89.)

So this was a case of only partly articulated experience and much subconscious and emotional experience in, but it was also a case of a lot of semiosis in as well in the form of the readings from the course and the professor's lectures as well as all the other things I had been reading and writing in those years. And there was semiosis out, too, in the form of the paper, but that paper articulated ideas I had never said before in ways I had not previously done. I wrote things that were surprising to me and that I did not fully understand at the time nor their import for me, though I knew the argument I was making about the plays and characters and how I structured the argument. But in the personal middle, in the internal processing of the impulses that formed in the writing, I was aware of only some of the parts and had no idea where some of the insights and formulations were coming from. I felt in such a drugged trance that although I could maintain the assigned structure of the four-play sequence with introductory statements and final conclusory-sounding statements and could follow through the evidence of the play scripts, there was a deeper force of meaning being worked out, a force that kept exhausting me and throwing me back into drugged sleep—but also compelling me to wake enough to write a few more paragraphs. The paper worked for the course with the teacher making extremely positive and to me moving comments, but I don't know that he had any inkling of how personally important this paper was to me or the moving force of his approving comments. Recently I looked at his published writings across his life, and they always stayed closely to the analysis of the texts and history of drama he was exploring, never even articulating the theoretical underpinnings of the argument, let alone their personal import or the potential meaning for him in understanding his life or the role of dramatic art in it. He seemed to me to be somehow communicating in the way I learned to do for his course, in a way that invited deep reflection on my part through the analysis of semiotic objects.

What occurs within the skin barrier is extremely important but baffling for writing, worthy of investigating. But in doing so, it is important to consider both the experiential and semiotic input that creates the problems, resources, motives, and persistent force that will eventuate in the production of documents. For scholarly and scientific knowledge, the shared disciplinary semiosis on both the front and back end, including the semiotic form by which new data is introduced, is especially important, even as we keep in mind that somehow, perhaps always, there is something more personal that directs one's attention to the world, inspires perception of problems, and drives the internal processing that will eventuate in the written statement that enters into a communal space of knowledge production.

## References

- Bazerman, C. (1984). The writing of scientific non-fiction: Contexts, choices and constraints. *Pre/Text*, 5(1), 39–74.
- Bazerman, C. (1988). *Shaping written knowledge: The genre and activity of the experimental article in science*. University of Wisconsin Press.
- Bazerman, C. (1999). *The languages of Edison's light*. MIT Press.
- Bazerman, C. (2012). Writing with concepts: Communal, internalized, and externalized. *Mind, Culture, and Activity*, 19(3), 259–272. <https://doi.org/10.1080/10749039.2012.688231>
- Bazerman, C. (2019). Inscribing the world into knowledge: Data and evidence in disciplinary academic writing. In C. Bazerman, B. Y. G. Pinzón, D. Russell, P. Rogers, L. B. Peña, E. Narváez, P. Carlino, M. Castelló, & M. Tapia-Ladino (Eds.), *Conocer la escritura: Investigación más allá de las fronteras [Knowing writing: Writing research across borders]* (pp. 279–294). Editorial Pontificia Universidad Javeriana; The WAC Clearinghouse. <https://doi.org/10.37514/INT-B.2019.0421.2.13>
- Bazerman, C. (2023). *How I became the kind of writer I became: An experiment in autoethnography*. The WAC Clearinghouse; University Press of Colorado. <https://doi.org/10.37514/PER-B.2023.1886>
- Bazerman, C., & Self, B. (2017) Writing the world to build the world, iteratively: Inscribing data and projecting new materialities in an engineering design project. In R. K. Durst, G. E. Newell, & J. D. Marshall (Eds.), *English language arts research and teaching: Revisiting and extending Arthur Applebee's contributions* (pp. 91–106). Routledge.
- Fahler, V., & Bazerman, C. (2019). Data power in writing: Assigning data analysis in a general education linguistics course to change ideologies of language. *Across the Disciplines*, 16(4), 4–26. <https://doi.org/10.37514/ATD-J.2019.16.4.18>
- Gitelman, L. (Ed.). (2013). *"Raw data" is an oxymoron*. MIT Press. <https://doi.org/10.7551/mitpress/9302.001.0001>
- Herrington, A. J., & Curtis, M. (2000). *Persons in process: Four stories of writing and personal development in college*. National Council of Teachers of English.
- Latour, B., & Woolgar, S. (1979). *Laboratory life: The social construction of scientific facts*. Sage.
- Merton, R. K. (1973). *The sociology of science: Theoretical and empirical investigations* (N. W. Storer, Ed.). University of Chicago Press.
- Pennebaker, J. W., & Chung, C. K. (2007). Expressive writing, emotional upheavals, and health. In H. S. Friedman & R. C. Silver (Eds.), *Foundations of health psychology* (pp. 263–284). Oxford University Press. <https://doi.org/10.1093/oso/9780195139594.003.0011>
- Vygotsky, L. (1986). *Thought and language* (A. Kozulin, Ed.). MIT Press.