acronym, spelled out in the text below Figure 2.2. Following the exposition and discussion of this work, the text proceeds to discuss my best current design for a Case Analysis Support Environment (CASE), embodied in a software shell I call RING. The conclusion then discusses the general usefulness of this environment for other kinds of text-based analysis.

A CASE ANALYSIS SUPPORT ENVIRONMENT

Motivation for the Work—A Technical Vision

It took me 10 years to bring my doctoral study to a traditional conclusion, one that can be represented by the publication of a coherent interpretation in books (Lawler 1985; Lawler, duBoulay, Hughes, & Macleod, 1986). Despite its commitment to empirical material, the study was theory driven (see Appendix A).[10]

During that same period of time, I began collecting materials for the corpus of a second case study. Why, while still overwhelmed by the task of making sense of one study, take on a second? Opportunity might be one reason, given that a child was born to our family then and the second corpus was, obviously, an infant study. More importantly, I saw there an opportunity to address a real issue and move it from the arena of ideological dispute into the study—although not the laboratory. That issue was the character of language learning and its relatedness or lack of relation to other kinds of learning.[11]

My second case study corpus was organized to track both the infant's language and sensorimotor learning in the social context of the home. The amount of material collected and inclusion of an extensive videotaped component urged on me the need to develop some computer-based tools to help with the administration and interpretation of such a large-scale case study corpora. I discussed this issue with Marvin Minsky at that time (Lawler, 1981), showing him the diagram in Figure 2.3, as my sketch for the kind of facility that could help support the analyst in an attempt to develop theories related to extensive areas of evidence. Minsky suggested I take seriously the notions of Nelson and consider "hypertext" as a candidate form of database organization for such a facility. I

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[10] It was my conviction then—and it remains so now—that the best work in the artificial intelligence community at that time, however lucid and elegant, was too remote from the details of everyday life to bring computational theories into confrontation with the complexity of the problems they tried to address. For contrast, compare Winston (1975) and Sussman (1975) with Barker and Wright (1955/1971). The question of how any computational machine (such as a human mind is) could cope with relations between the messy richness of details in experience and possible complexities of representation was one of the issues generating Minsky's (1975) well-known paper "A Framework for Representing Knowledge."

[11] That issue was somewhat contentious at the time. Witness the discussions between Piaget and Chomsky and their colleagues at the Royaumont Abbey. Some aspects of that debate are preserved in the book *Language and Learning* (Piatelli-Palmerini, 1980). The issues are not resolved.

did so, a few years later summarizing my appreciation of the possibilities of such an approach in the text here as Cameo 2, "Would-be Sciences."

CAMEO 2. WOULD-BE SCIENCES

Science mainly . . . advances by leaps; and the impulse for each leap is either some new observational resource, or some novel way of reasoning about the observations.

—C. S. Peirce (1957)
Lessons from the History of Science

Scientists eager to learn through frontier research often seek studies where some "breakthrough" may push a would-be science across the border to scholarly acceptability. In contrast with efforts that attempt to define by principle what is and what is not science or to classify by distinction varieties of science, Peirce's description of the quintessence of science as convergent opinion is our surest guide in evaluating those areas of inquiry that may be emerging as fields ripe for scientific development.

The study in detail of individuals' development, the psychology of the particular, provides a lucid example of a kind of research that today profits from both those impulses to which Peirce ascribed scientific progress. In respect of observational resources, recording technologies now make it possible to freeze samples of behavior in context and in time. Case study corpora now can be duplicated and shared with others for a more thorough public examination of detailed records of behavior. From the longer view of an extended research community, individuals' case studies can be seen less as magna opera and more as public and sharable experiments available for interpretation later, even though not amenable to replication in detail.

The twin foci in contemporary cognitive sciences on explicit representations of knowledge and functional modeling of behavior represent new ways of thinking about cognition and its development; new ways, even, of defining what is to be explained by such research. The embodiment of partially interpreted studies in hypertext (databases of richly interlinked records with functioning models as needed) permits their sharing and annotation by other scholars; various interpretations may now be compared publicly and evaluated with a flexibility never before possible. Such tools also permit the better management of extensive and intricate corpora. If we can construct sufficiently complex and detailed functional models of behavior, we may even have the ambition someday to develop general theories able to explain how unique incidents of learning happen for a particular person in a specific context.

It may take a while for opinion to converge to that truth we seek, and any would-be science may remain so forever. But this fact is merely a practical difficulty and not an impasse. The guidance provided by Peirce's views is some

comfort to those of us who spend a life with the would-be sciences, even though we may need frequently repeat with Emily Dickinson:

How small a thing to drop a life
Into the purple well
Too plummetless that it return
Eternity until.

(Autumn, 1989)

What Was Done—A First Attempt Made

A report of the first effort in this direction appears in Appendix B. In summary, after various divagations, I had a short opportunity to begin constructing a CASE facility using the Notecards software environment on a Xerox Dandylion.[12] During that period I was able to create a catalog of the information in the corpus and to bring online a portion of the text records of that corpus. I began organizing the text into a hypertext database (see Figure 2.4 for a sketch of the general structure; more detail is available in Appendix B). Notecards was clearly a very powerful and general tool, much moreso than the later Macintosh Hypercard, which it, among other influences, inspired. For me, the issue became one of its usefulness for my specific ends. The agency supporting my research grant was less interested in my study, as such, than in the general question of whether Notecards could in fact be used to deal with inchoate masses of information.

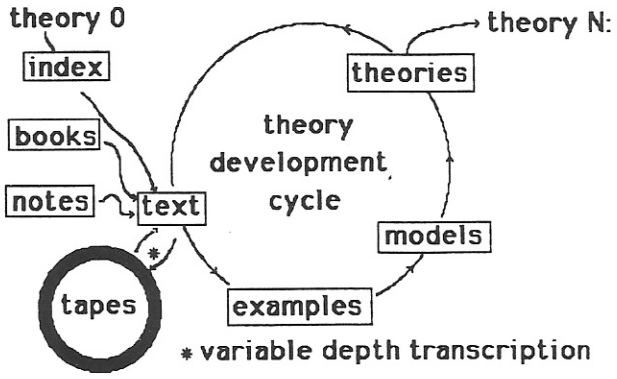

Figure 2.3. A case analysis support environment.

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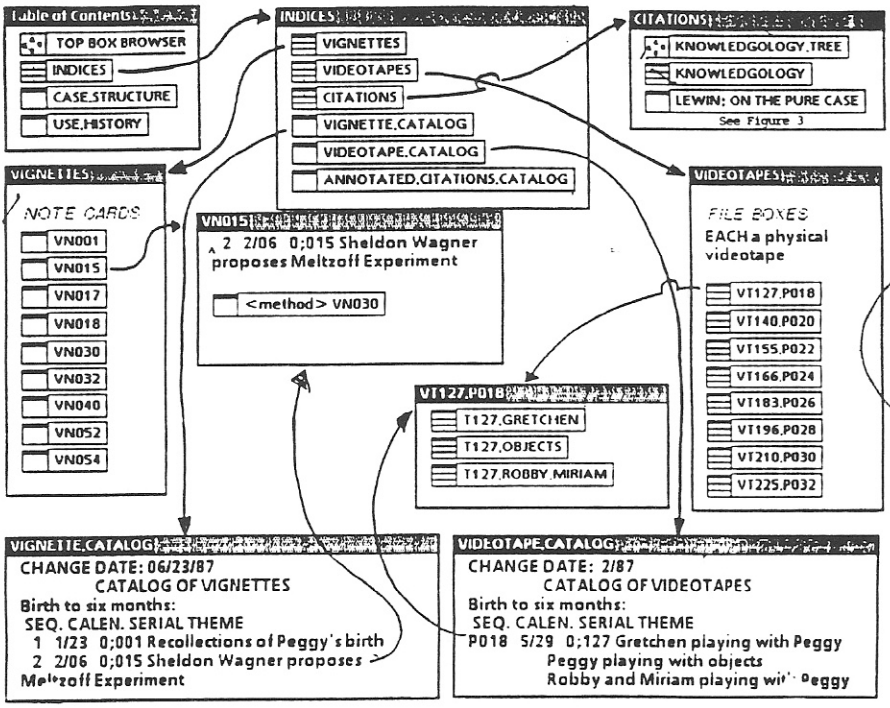
[12] This effort was funded by the National Academy of Sciences through a grant to me as a Senior Research Associate in residence at the Army Research Institute for the Behavioral and Social Sciences. After 6 months in this position, I entered academe as a professor at Purdue University.



FPO

Ed: Please supply final art on disk

Figure 2.4. A first case implementation.

What Was Learned

It may be easy to make a hypertext database. It is more difficult than I imagined to exploit the power of hypertext linking for a serious application. Why? The complexity of the application itself requires a comparable complexity in the database structure. Theory development is hard; for that reason, it is hard also to design a facility as an aid to theory development. The critical difficulty is that case interpretation and theory development are progressive and interactive: One does not know beforehand what the ultimate categories are to be for the classification of elements. Further, if you begin by creating a structure based on prematurely chosen link types, you lose the organizational flexibility that is one major reason for using hypertext in the first place. The tool can be a trap.[13]

The actual uses of hypertext links. Because the study was developmental—and thus time was a major organizational dimension—the links I actually used in organizing the material were like temporal threads running through the databases: They permitted pulling up the text chunks in temporal order depending on the issues I was interested in considering. They typically were parts of

[13] This observation parallels a familiar lament of computer users. The adoption of a computer environment entangles users in constraints that inhibit flexibility needed for new applications at a later date.

developmental sequences and had labels such as *language*, *cognition*, and so on. What they meant was "this piece of text contains information that bears on issue of general type X." I could have done as well with a two-column list on a piece of paper. This was disappointing.

The naming of link types was not sufficiently flexible in a specific sense; it was assumed that a word or a short phrase would adequately represent the type of the link and that these categories would be generally useful. Categories that can be encoded with such simple descriptions are at too remote a level of abstraction to help an analyst who is not sure of what he is looking for. The sorts of labels I had to use in order to generate any commonality of reference were all so general that they served almost a purely indexing function. The hypertext "typed links" of Notecards were functioning in my use as little more than index entries of minimal power.

In retrospect, I can see that I sensed then a need for intermediate kinds of structures; some kinds of links that would help me note and remember fleeting observations and insights about what I could see in the material and the relatedness of those observations to the still developing ideas that were guiding my exploration. Categorical link typing was too remote from that essential process to be useful to my effort.[14]

A Decision Point

My general conclusions from this effort were two. First, the existing facilities for hypertext were not especially useful for someone dealing with a corpus at the relatively unprocessed state of my infant study. One had to be much further along in the development of a theory before structuring materials by categories would be useful. Second, I was so remote from being able to interpret or to model the infant study material that I should defer the effort to work with an example that would help me build a CASE. You need to be able to represent at least one state of a system in order to build a facility for supporting a developmental cycle.

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[14] This fact does not embarrass me, though a critic might consider me stupid or ignorant for not believing in his accepted theory or for not using existing facilities to attach notes to specific words. My confusion was of a more general and common sort. Like a child who had not yet achieved that balanced knowledge we call "conservation" in Piagetian psychology, I found myself confused by a myriad of possible interpretations of what might be the nature of the specific phenomena I confronted and what material might bear on the issues. If you do not understand the whole phenomenon, how can you tell what the significant parts are or how the elements relate among themselves? How can you tell what is the significant thing that is to be conserved? No one "conserved" the quantity of energy before Joule and Kelvin in the 1860s or the speed of light until Einstein first did so in 1905 (of course, Fitzgerald and Lorentz had noted, earlier and speculatively some of the implications that might follow if the bizarre hypothesis were the case that the speed of light was a universal constant).