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Relating Modes of Thought

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Switching Worldviews: Stages of Learning

> There are two kinds of people in the world, those who believe there are two kinds of people in the world and those who don't.
>
> Robert Benchley, Benchley's Law of Distinction (1889–1945)

When I first read Robert Benchley's Law of Distinction in a grammar school English class, I enjoyed going around saying, "There are two kinds of people in the world, those who agree with Robert Benchley and those who don't." This recursive joke captures the essence of switching codes[1]—there are two kinds of worldviews, those that allow for multiple worldviews and those that don't. Or as Benchley might have put it, there are two kinds of people, those who believe in the integrity of multiple worldviews, the pluralists, and those who don't, the objectivists.

Although theories are thus easily named and distinguished, people's beliefs are not. The three chapters in this section ("Ontology, Semantic Web, Creativity") illustrate quite well that, rather than falling into two obvious camps, people can straddle and blend worldviews. I will gloss the complexities a bit by labeling the three chapters as representing stages of learning, "Get it" (Cuesters and Smith), "Getting it" (Hendler), and "A glimmer of hope" (Ganascia), relative to the perspective that different worldviews are possible, legitimate, and useful for relating technology to the arts and humanities.

A nice positive story would probably end on a happy, triumphant note with Ceusters and Smith, rather than what in my opinion is an early-stage struggle—Ganascia's sincere exploration that just begins to uncover the possibility of a nonlogicist worldview. But an easier and probably more concise analysis would start with Ceusters and Smith, so that what I take to be the standard is clear; then Hendler's progress would be evident, and the gap over which Ganascia peers more broachable. So I will opt for lucidity over a happy ending and apologize in advance for sounding moralistic.

Cuesters and Smith show us how multiple worldviews—conceptual-representational "codes"—can be related, transforming each other. Hendler tells us the story of transition, of realizing error, and finding another way. Ganascia shows what it's like to begin the journey, the difficulties that loom and why progress requires a transcendent leap—an acceptance that the worldview of the technical rationalist is not sufficient to be useful in human activity, and indeed that some of its tenets must be rejected in the face of new interests, values, and community purposes.

My conclusion is that technologists and artists, as well as different kinds of scientists, are "blending codes," and that in many respects the switching that occurs is from the objectivist worldview to the pluralist. In practice, this means that the logicist-technologists—represented here by the logical induction and semantic web researchers—have the biggest change to accept. Once the technologist believes that there are "two kinds of people in the world," then the dance begins.

Ceusters and Smith: Toolmakers Who Know How to Dance

The work of Ceusters and Smith exemplifies what it means to "get it," to straddle points of view, to live in multiple worlds, blending interests and communities, theories and skills. In contrast with the original intent of AI ontologists—to develop expert systems, programs that would replace human experts—they ask, "Can ontological engineering help us to understand what dancing is all about?" They seek to use modeling technologies as a tool for human learning, not as a substitute for human action (automation). Rather than seeking to codify and bottle knowledge, they seek tools that will facilitate inquiry: "[One] might like to know the name of the particular dance depicted [in a video] so that he can pursue questions concerning its region of origin or choreography." Recognizing the conundrum of the knowledge engineer, they realize that ontologies can provide a framework for developing a new theory: "to 'represent' dancing in the computer, we must first have a good insight in to what dancing *is*."[2]

In Ceusters and Smith's worldview, knowledge is dynamic, adapted, and reproduced: "The earlier, folklore model supported scholars and institutions in documenting and preserving a record of disappearing traditions. The intangible heritage model, by contrast, aims to sustain a living tradition by supporting the conditions necessary for cultural reproduction." They contrast the "traditionalists and innovators," distinguishing preserving from nurturing, like the difference between canning food and promoting gardens: "Our past and our heritage are not things preserved for all eternity but processes that must constantly revalidate themselves."

Ceusters and Smith recognize as well the complexity of communities within communities, the blending of local identity and global assimilation, the dynamic of speciation and ecology: "[Dances] contribute, on the one hand, to the blossoming of cultural diversity and the enrichment of specific cultural identities, while on the other hand, their plasticity renders them capable of nourishing the dialogue between and intermingling of disparate cultures." Another kind of dance develops between the opposing processes of objectification (distinction) and relation (assimilation): "respecting their national and regional diversity and at the same time bringing the common cultural heritage to the fore" (here quoting the Treaty on European Union).

Similarly in their use of ontologies, Ceusters and Smith embrace the discourse between naming/identifying and creating/expressing, the dance between the thing being created and the process of creation. In sketching a tool with many layers of representations, their conception of dance ranges from the dynamics of the individual body to the dynamics of the culture—they speak of "human motion," "dance motions," "sorts of dances," and "dances' evolution over time."

Their understanding of theorizing is sophisticated; they recognize the possible confusion between talk about experience/activities and talk about the map—"confusing the classification of entities in reality with the classification of words or data describing such entities." In their discussion, we see how different systems or domains of action require different languages for articulating, modeling, or guiding action. In advocating the use of a "kinetic language," Ceusters and Smith explain that "it is the movement itself that is conveyed, rather than some analytical, functional, scientific, or poetic verbal description." This awareness reflects experience in switching codes, respecting the difference between action and idea, the territory and the map, and all the many layers of these from deed to concept to remark to theory.

Dance as a domain of inquiry, contrasted, for example, with medical diagnosis, promotes a broad perspective on the nature of data. Hence, Ceusters and Smith use multimodal recordings and integrate layers of representation: motion, tempo, sound, actions. Accordingly, they are engaged in adapting and creating standards that relate complex spatial-temporal details.

And so from the theoretical framework of how a tool would be used (e.g., enhancing experience) follows the nature of the representations and then the formalizations. This turns the technical world on its head, reversing the process of developing standards as ideal pots into which arbitrary applications will fit. Here again, in developing standards, Ceusters and Smith realize that different systems or domains of action lead to different languages for articulating, modeling, and guiding action.

But just as no dance is ever finished or perfected, the dance between ontological theory and practical purposes is for everyone an ongoing project, here and there with rough edges, some puzzles, and if we are lucky, unexplored territory. For example, Ceusters and Smith cite Ingarden on the work of art as "a complex stratified object that is neither physical nor mental," but rather *both* physical *and* mental. Here I am reminded of Wilden's orders of complexity, which he called a "dependent hierarchy" relating inorganic nature to culture. In this hierarchy, open systems, such as society/culture, "depend for their existence on the environment of the higher ones," such as inorganic/organic nature (Wilden 1987, 74; Clancey 1997, chap. 10). Like an individual person, a dance event doesn't fit into the hierarchy because it is physically and teleologically a complex of multiple orders of complexity, that is, both inorganic/organic and cognitive/social.

One can also quibble about a few other remarks, perhaps just slips. Ceusters and Smith refer to "correct analysis" without qualification about the purposes or context that make the analysis useful and hence valid. Their reference to "users" is technology-centric; I'd prefer they stick with "dancers" or "learners." The paper lapses into business-case technology talk at the end—"enable speedier recovery of data and facilitate its analysis"—while everywhere else, the focus is on a tool for creating information, providing a means of seeing, comprehending, and reproducing dance.

Finally, Ceusters and Smith could benefit from a theoretical framework that better relates data and information. They write about "bridg[ing] the semantic gap between the information that the computer can extract from given multimedia material and the interpretation that would be useful to a human user," when they really mean the gap between the data and the information (interpretation) conceived by the learner. Their inquiry could perhaps benefit from a framework for relating perceiving and conceiving (see Clancey 1997, chap. 4) and Dewey's (1938) notion of inquiry, which might help them better relate learning to see, learning to hear, and learning to move.

Yet overall, Ceusters and Smith masterfully navigate the worldview of dance, as physical, social experience and cultural phenomena, with the worldview of technology, as a tool for articulating, sharing, and adapting ways of perceiving, conceiving, and acting in the world. It hardly gets better than this.

Hendler: Learning to Switch Partners

Hender, by comparison, is "getting it"; he is a technologist engaging with another worldview. He tells us about a reluctant switch from pursuing his technological ideal (the semantic web) to dealing with the facts of the world ("from the bottom up"), but he is a bit unrepentant and sometimes indignant about the reality he discovers. This makes Hendler an ideal informant about the journey involved in "switching codes," for he still lucidly remembers how he used to talk and think and the tools he built. He remembers what it feels like and is still tugged back by previous ambitions and projects. But he is making progress, finding a new way in new kinds of activities with different groups of people.

Hendler wonderfully lays out the struggle felt deeply among the logicist community when confronting the web, the astonished recognition that something messy, full of discrepant facts and fallacy, could be useful! The scale and nature of interactions on the web is so unprecedented, there is no point in merely arguing that all these people are wrong and building a house of cards. Adopting an "if you can't beat them, join them" approach, Hendler and others have converted to an empirical framework for developing technology. Previously they believed that a logical/formalistic framework for representing knowledge was required: With a set of contradictory propositions, anything could be proven true. Technical rationality (TR) demanded purity: definitions, consistency, completeness. TR demanded a mathematical foundation for validity.

But in studying the web and trying to make a useful contribution, to participate with his tools, Hendler has developed a different rationality, one that motivates making tools that are valued in an activity, what he calls "relevation," making something relevant—in this case, making the semantic web relevant to modern life.

Articulating the human-centered computing perspective, Hendler says, "Many of our assumptions about how we represent knowledge for processing by computers have held us back from really understanding human use of knowledge." In other words, the focus on codifying and preserving knowledge has distorted our understanding of knowledge; developing expert systems and then ontologies as repositories was grounded in an invalid epistemology. Perhaps the AI of the 1980s was logical, but it wasn't relevant, it didn't establish a connection with knowledge as it actually lived in communities. Knowledge engineering wasn't useful.

In studying the nature of the web, Hendler is coming to realize that he is dealing with a conceptual system, a "code," not "knowledge" as he previously understood it, as articulated facts and theories. And possibly he is starting to see that people don't *use* knowledge, but rather knowledge is manifested in action, recognized, adapted, articulated, conveyed (an argument famously presented by Ryle 1949).

Previously, Hendler thought there was only one set of knowledge, one truth, one point of view, that is, one code. The standard of truth in science and professional practice was the notion of accuracy, the relation of diagnosis and prediction to reality. Because there is only one real world, there can only be one true set of theories about the world, and so all ontologies must map onto one another—the economists' ontology onto the physicians' onto the bureaucrats' onto the politicians' onto the psychologists' and the archaeologists' and so on. The progenitors of the semantic web envisioned one grand dictionary of terms, all the vocabularies properly tied together in definitions that mapped names to meanings and theories. Indeed, the semantic web was to be a veritable Babel of logic, unifying the languages of thought of all peoples, reaching the heavens of true knowledge.

Now Hendler finds that web postings cannot be made consistent and reliable in an effort to "establish truth"—not because they are mistaken or even deceitful (though this still irks him), but because the different points reflect different values, concerns, motives, and activities (Schön 1979). Consider, for example, modeling a computer system in a university: what constitutes "the system" and how it is described in terms of issues, decisions, regulations, and so on, depends on the "code," the systemic perspective, the conceptual system that frames the analysis. A variety of analytic perspectives are possible for talking about (viewing) computer systems, some of which are easily related because the communities work together and others of which are incommensurate: VLSI, software, network communications and services, facilities management, capital investment and inventory, academic infrastructure, ergonomics, energy, instructional design, security, privacy.

Perhaps the first realization about multiple viewpoints arises from seeing one's own ideas and methods applied in unexpected ways. Hendler's reaction is dramatic: "This web AI was antithetical to the very stuff of which KR&R [Knowledge Representation & Reasoning] was made!" Eventually, he realizes that the "AI" technologies of the web originate in activities, social contexts, not in individual expertise or "knowledge." He has the fundamental insight that multiple worldviews are possible and may coexist: "The need to organize knowledge in some formal way . . . is only one way to approach things, especially when there are social processes in place." As Benchley would say, Hendler now believes that there are two kinds of people in the world.

Perhaps most importantly, Hendler recognizes how the essence of the web is to facilitate switching codes: “By being able to, even heuristically, equate things found in different web applications, a whole range of mash-ups and other web applications becomes possible.” Because of the combination of contextual information (e.g., topographic maps of California) and scale (e.g., dozens of weather stations posting current data in the San Francisco Bay Area), crossing and intersecting occurs that enables people to notice patterns and relate contexts (e.g., it is warmer on the east-facing spine of the San Francisco peninsula than on the Pacific coast or in Silicon Valley).

But the Pygmalion dream is difficult to forget. Hendler is still driven by creating technology, he is a toolmaker: The web provides “new and exciting possibilities for a very different class of (just a little bit) intelligent systems.” Yet what is the purpose of web technology—to charm us with intelligence? Or for people to experience and find stories, videos, photos, beauty, ideas, and communities? Is the designer of “social networking” centered on the technology or the people? In straddling worldviews, Hendler seems to move back and forth between these intentions, as creator and facilitator, one who controls, making the world tidy and right, and one who nurtures, making the world more lively, dynamic, personally and socially authentic.

The section “But Is It AI?” reveals Hendler’s born-again experience. He develops an important insight about people by analyzing the web as a social artifact. The web “grew from the interaction of human beings sharing information." This is a powerful idea: sharing and interaction, building on each other, commenting, collecting, pointing, packaging each other's work.

But people are not just *sharing*, they are declaring, marking, singing their personal expression—the web becomes like the cacophony of the jungle, where birds of a feather can find each other through their postings. The web is emblematic of human intelligence, the very topic of AI, presumably what Hendler had been trying to create for decades. Expressing his amazement at landing in the real world of people, he says, "Human intelligence violates many of the traditional assumption of the field of knowledge representation." Although he doesn't delve further into the paradigmatic change, these are the very arguments that were so controversial in the 1990s among those proposing "situated cognition," arguments that human knowledge (conceptual memory) does not consist of stored models.[3]

Hendler's understanding of what his observations mean, in terms of both cognitive theory and his own professional practice, was still in flux when he wrote this chapter. From the situated cognition perspective many of his thoughts could have been more developed. He says, for example, "Human intelligence evolved from dealing with [the real world] (and with other humans)." Indeed, human intelligence evolved from dealing with the world *with other humans*, in activity that was inherently joint and transactional (e.g., in a poker game of projected intentions and anticipated projections, actions based on beliefs about the prey's—as well as interpersonal—motives and habits). When Hendler writes about "physical tasks, cognitive tasks, societal tasks," he doesn't admit that being a person sometimes doesn't involve doing a task at all. To take an example close at hand, consider dancing.

Still caught in the formalist notion of inventorying knowledge, Hendler writes, "No one knows the number of concepts involved in human thought." But why should concepts in principle be collectible and countable? Could we count all the dance forms that are possible? All the ways of dancing that people currently practice? In what worldview are conceptualizations—ways of coordinating behavior in different modalities—*things*? The objectification of the observer in naming and classifying looms large in Ceusters and Smith's discussion of pitfalls but does not arise here.

The real leap for Hendler will come not from a better epistemology alone but in recognizing that empiricism, working "from the bottom up," does not mean just learning about human intelligence (particularly to replicate it) but facilitating learning. I kept wanting to ask, are you monks or entrepreneurs?

Here indeed probably lies the crux of the difficulty. As one colleague put it in the early 1990s, "They need to know what to do on Monday." Hendler explains the difficulty of switching codes: if our assumptions have been wrong, how can we change "without losing what rigor the field has been able to achieve?" Rather than throwing out the logicist way of talking, the notations, and the tools—and most fundamentally, the community's values—logicists need to put them to new purposes. Eventually, this will involve reframing, appreciating in a new way, what they have accomplished: The AI discipline created a very general tool (qualitative model representations and operations;

Clancey 1986, 1992) that was originally invented for codifying and distributing knowledge but can now be used for creating new understandings and ways of interacting.

The shift required of the technologist is dramatic. As Hendler says, “The real world is not the world that KR systems were built for”—a nice encapsulation of the multiple worldviews. Originally, the metaphor of consultation dominated the AI field of expert systems; that is, the researchers' vision was that people would consult with expert systems, which would give advice or perhaps teach them. This metaphor probably stemmed from the professional settings that inspired building expert systems and the people with whom AI researchers worked—physicians, oil-field geologists, and electronics troubleshooters. In replicating the knowledge of these people, researchers tried to replicate how they worked, or at least how they assumed their work was done: with verbal inputs and verbal outputs in a consultative dialogue. That fit the single-modality verbal view of knowledge very well. The idea that expert systems needed to be actors in complex social interactions was invisible or ignored (e.g., Greenbaum and Kyng 1991; Clancey 2006; Clancey, Sierhuis, and Seah, 2009).

What I most like about Hendler's chapter is how he so plainly and honestly articulates his confusion. He is torn by the values of technical rationality. He now lives in a somewhat disturbing world: “It is certainly not the case,” he acknowledges, “that quality always wins out.” But what is quality? In contrast with the absolute “truth” metric of the logicist's worldview, the quality of a model on the web is contextual, relative to the functionality or usefulness of a model in a community of practice. More than "humans pursuing multiple goals," people have incommensurate goals, multiple points of view, different ways of framing their lives and even their activities within a single community. The web is not just a messy pot of data; it manifests an infinity of pots.

Reading Hendler, I am a bit overwhelmed by how caught one can be in formal notions of quality. While "expressivity" can be a useful perspective for evaluating notations for some activity, is Hendler right to say that a child is "inexpressive" because he is not verbalizing in the same way as an adult? Might the child be expressive in other modalities, conveying emotional experience through gesture, tone, facial expression? Verbal articulation—modeling the world in fact, causal story, and theory, as the logic formalist requires—is one way of characterizing the child's communication. Compare this adherence to verbal representation with Ceusters and Smith's use of multiple modalities for characterizing dance. One of the most insidious traps of the cognitivist/logicist camp is the representational flatland of verbal models. All knowledge, reasoning, representation, decision making, and so on are viewed as transformations of linguistic expressions: speech, conceptual maps, semantic networks, predicate calculus, and so on. Even interpreting diagrams is reduced to verbal manipulations (Clancey 2000).

Thus Hendler proposes using the model-based point of view to guide people in providing information useful for model-based decision making ("you can react appropriately"). But to exploit the logicist technology, one needs to respect the nature of points of view and the nature of knowledge, plus reframe the nature of knowledge-based (modeling) technology. That's a lot of reconceptualization and juggling of conceptual spaces, inventing new ways of using tools, and finding new partnerships—not so much "switching," unfortunately, as inventing a new life, a new practice.

At the end, it's unclear whether Hendler has accepted the shift to working with the web rather than trying to reform it. Regarding how to handle "scaling, quality, and inconsistency . . . when these issues arise together, and at huge scale," he says, "We need a different approach to the underlying formalisms . . . that attacks rather than ignores these critical features of human interaction." Why not formalisms that embrace, complement, work with, leverage, or expose these aspects, as a tool? But then, in the very next sentence, the "attack" has become an "exploration." So perhaps in saying this, in responding true to formalistic thinking, then equally clearly stating a new resolve for action ("What do we do?"), a conceptual resolution is developing. In my experience this reconceiving occurs naturally in a back-and-forth reworking, like climbing a wall with two ladders, your footing alternating as you grasp and transform different conceptual systems, reorienting your attitudes, attractions, and direction.

Somewhat unexpectedly, Hendler's bottom-up approach shifts from beating logic into the web to joining the enterprise of making contributions. So now groups of semantic web researchers are working in parallel and sharing their work on the web. Engaged in this activity, Hendler recognizes that what counts as correct (factual) or as a good argument depends on the community of practice, and that automated "reasoners" need to evaluate claims by "figuring out what fits best into your worldview." Notice how the second-person reference ("your") mirrors Hendler's own recognition: a program must respect what he himself has come to realize. The web is an environment where you need to be skeptical, and one way to accomplish this is to work cooperatively. Hence, what is involved is perhaps not just multiple reasoners with different worldviews but reasoners who live in different worlds.

To summarize, Hendler's worldview with regard to knowledge and technology was: Be formal or be irrational. His new view is both cultural *and* formalized. Yet he doesn't talk about metaphors, framing, modalities, values. He does mention worldviews but hasn't functionally (productively) factored this into the activity of the web and his own activity. He's trying to figure out *what to do* and that requires figuring out *how to think* about the web.

Hendler doesn't quite articulate how formalism is one game among many, but his interest has plainly shifted from the game board of technical rationality to the empirical, yet in part intangible, world of human action (i.e., culture broadly). In his former world of technical rationality, formalism rules—it enables the world to be rigorously controlled, providing consistency, truth, order. Hendler's journey makes us wonder, what was the motive of the formalist worldview? Bringing truth and order to the world?[4] Providing tools for others to do this? Has evolution provided some special proclivity for this accounting mentality, this verbal orderliness?

The world of the web being discovered by Hendler is divergent, personal, consisting of many communities, involving expression of the self and values, and regulated in many ways (technical, institutional, and informal). The web is dynamic, evolving; it is an instrument for learning on a global scale, comprising a medium and many activities (browsing, blogging, studying, buying, etc.). The effect on humanity is no doubt already profound, and having started in my own work, like Hendler, dominated by the code of technical rationality, I am inclined to say the upheaval is probably most felt among AI researchers. For while others gain new tools, our very livelihood has been called into question. But the rewards of this inquiry are many. At the heart of Hendler's struggle are classic questions, What is quality? What are my motives? How do I find purpose in life? What is my niche?

Hendler's essay ends on a courageous, hopeful note, an unmistakable first step. But he is not yet in the domain of the web creator and browser/reader. He is not fully committed to providing useful tools. In the words of Ceusters and Smith, the real transformation will come through meeting the "real-world needs of large communities of interested persons." The result will fit Hendler's original focus on knowledge. As Ceusters and Smith go on to say, such tools, "not only contribute to the quality and quantity of information available online but also yield deeper scientific insights." Hendler could be headed here, viewing the web as a source of data for theorizing activities, for example, for developing better medical care. Doing this requires becoming engaged in a partnership, following the principles of participatory design (e.g., Greenbaum & Kyng 1991).

The next step is to make a commitment to serving others, rather than readjusting the deck chairs on the R.M.S. *Logicist*. Without a meaningful activity, an encounter in partnership, Hendler's community will just be wearing a different garb, not really having been transformed, not really having crossed a disciplinary boundary. That change will not occur until the logicists actually try to dance with people in another community.

Ganascia: Dancing with Logicist Eyeglasses

In comparison with the work on dance and the semantic web, Ganascia's study of human creativity provides only a glimmer of recognition that multiple "codes" can be used to model and organize human activity. He wants to relate human creativity to logic and anchors his argument on certain aspects of creativity: growth, conceptual mapping (prior knowledge), and surprise. But he tries to establish the relation between human creativity and logic in the space of logical formalisms itself, grounding his analysis in certain computational metaphors (e.g., "memorized structures") rather than the real world. His approach is not empirical; rather than studying the creativity of dance or social networks and seeking to relate these phenomena to formalisms, he deals with puzzles, syllogisms, and data sets. There is no mention of Gardner's (1985) dimensions of intelligence, multimodality, practice/norms, instruments/tools, notations/models, and so on. The embodied notion of cognition (see Ceusters and Smith) and its social character (Ceusters and Smith, Hendler) are absent.

In short, Ganascia's notion of knowledge, reasoning, and action adhere to the traditional information-processing perspective, making no distinctions between knowledge and models, conceiving and logical inference, meaning and formalism, experience and computation. This is the very world that Hendler tells us does not fit the reality of human creativity.

Ganascia's article is about a struggle to relate logic to human creativity. But how creativity is defined depends on the worldview within which one characterizes the nature of *change*. Altman and Rogoff (1987) distinguish three worldviews—interactional, organismic, and transactional—that differently frame how scientists formalize "relationships between (a) the reasoning agent, (b) the agent's environment, and (c) the observer of the agent and the environment" (Toth 1995, 345).

Ganascia recognizes at least tacitly the role of the observer in defining creativity ("one of the criteria . . . is the capacity to surprise"), yet seems to view creativity as an objective property of an act, rather than as a relation among agent, environment, and observer (the transactional view). Somewhere a theory of creativity needs to discuss point of view. Although the observation of creativity may have something to do with "unexpected elements," to the learner creativity is about value, whether it be aesthetic or functional.

Working within the interactional worldview, Ganascia attempts to relate human creativity to logical inference, and notes some puzzles. The glimmer of another perspective arises in his inquiry—a worldview that includes formalism as a tool used by persons, rather than being the substrate and mechanism hidden inside the brain.

Ironically, reading Ganascia tells us something more about the creative process, both through his own work of understanding creativity and the reader's work in understanding his inquiry. "Unpredictable, and therefore creative," he writes at one point, and then, "artistic creation has to be simultaneously unpredictable, harmonious, and familiar." I am jarred; these phrases seem contradictory, lacking in what I take to be common sense about creativity. Apparently this is so for Ganascia too. In making these statements and raising these questions he is expressing the horns of a dilemma, his own bewilderment over the disconnected pieces of his story—our experience of how creativity works, on the one hand, and our definitions and theory of what makes a work creative, on the other.

So we need to jump out of this hyperrational circle and ground our inquiry; we need to find something this inquiry could be *about*. Let us go back to experience for a moment. Consider the mixture of randomness and deliberately patterned coloration in Jackson Pollock's abstract expressionist murals. At first (in the late 1940s) they were not familiar at all, and perhaps this made them interesting. Did dripping paint on canvas qualify as painting? Later the very familiarity made Pollock's paintings valuable, but we might question whether they are still surprising or unpredictable.

Cultural-historic context plays a major role in what is viewed as creative. Genres, as norms, establish boundaries and new opportunities for surprise.

Considering the periods of impressionist, cubist, and expressionist painting from the late nineteenth century into the twentieth, we see that a work is not evaluated in isolation but in the context of the period, as an example of a genre or movement, and perhaps as a commentary on another style or work (e.g., the nonrepresentational form of Mondrian), a variation on method (the relation of van Gogh to pointillism), or an exploration of an idea (the series of Monet's lilies and haystacks). The relation among works provides a conceptual space for framing a new work; a work is not just surprising or unpredictable but very often bears a deliberate relation to the context of prior work. A particular work is often reinterpreted as the historical context itself is reconceived (e.g., reinterpreting Picasso's last works as a form of "neo-expressionism").

How could a computer program that paints be creative if it has no notion of prior work, if it is not part of a community of practice? I have argued (Clancey 1997, chap. 1) that Harold Cohen, an artist, is part of a community and that Aaron, his computer program, is a tool for him to generate works, through his tweaking of parameters and selection of paintings to exhibit (Cohen signs the drawings). Further, by studying drawings generated by Aaron and understanding the program's limitations, we can better understand the difference between a logicist machine and human conceptualization (thus I believe Ganascia's section heading "Creative Machines" is a misnomer).

Several years ago, to better understand Aaron's drawings, I generated thousands of pictures from a version available on the web and studied them, to an extent reverse-engineering the program.[5] It is true that every drawing is different. However, there are distinct categories: drawings with three people (no pots or plants), two people (with one obscuring the other), one person (alone or with a plant), one plant (no people), and one or two pots (no plants or people). Men are always in front of plants; women may be totally obscured by plants (fig. 15). When the pots are empty, there are always two, and they are the same color. There are no drawings of four or more people, no drawings of two plants or three pots. The rear wall may be mottled in the Tuscan style or appear as a painting itself, somewhat like the abstract expressionist style of the original Aaron of the late 1970s.

FIGURE 15. Eight selected drawings from Aaron (Clancey 2005, 5).

Yes, the configurations are often interesting to look at and the colors usually pleasing. Perhaps a street artist might make a living selling them, but after glancing through a portfolio of dozens of these images, I believe you would have a sense of closure, of having seen it all. The program's ontology—people, pots, plants, walls, and a floor—is fixed; in Ganascia words, "the support of the search (that is, the conceptual space) has already been given." Nevertheless, the procedures for creating "plausible representations" from this ontology are quite complex (Cohen 1988; McCorduck 1991, 201–8). The variation we experience in the images comes from the relative size of the people, plants, and pots and their placement in the frame. Postures may vary within bounds: hands on hips, to the mouth, or on the chest. But nobody stands with one foot in the air. Coloring constraints add another layer of variation and hence interest to the drawings.

One might wonder, if van Gogh could have drawn thousands of drawings in a day, whether we would find similar patterns. The point of course is that people learn; they are not bound by today's conceptions. They can generate new categories and, as I emphasized, new ways of using categories and materials to comment on previous works of the self and others. (For example, in the mid-1980s Cohen created a variation of the Aaron program that drew pictures of multiple Statues of Liberty instead of plants and people.)

Does Aaron satisfy Ganascia's quest for a "general method somewhere between totally predetermined generation and purely random behavior"? I believe so, for although the categories are predetermined, the placement and size of elements is random (within set bounds; Cohen 1988, 851). But there is a difference between rules in a program like Aaron and human conceptualizations. Conceptualization, in a manner we do not understand well enough to replicate in a computer program, enables a kind of "run time" generation of patterned behavior that is always potentially new, not restricted to random variation on some fixed number of parameters but meaningfully adapted to multiple overarching conceptual concerns and coordinated in different sensory-motor modalities (sound, image, posture, rhythm) in time (Clancey 1999). That is, human behavior has an improvised, dynamic nature whose patterns are modeled by programs like Aaron, but whose neuropsychological mechanism is not yet understood.

One puzzle presented by Ganascia is that "the output of a creative process has to contain more than was given as input." Yet creative generalization, he says, "entails the loss of all of the specificities of the particular.. . . Induction corresponds to a reduction in knowledge." Surely this contradiction between "more than" and "reduction" must be a clue that the theory has gone awry, and I assume this is why he articulates these statements, laying down the troubling implications of the interactional (input-agent-output) worldview for understanding creativity.

But Ganascia's analysis seems not to advance as it might, appearing caught up in a too limited, almost circular notion of information, knowledge, and learning. I would suggest a more scientific approach, starting with observable phenomena, even those generated by a machine. For example, do Aaron's drawings "compress information"? Don't they in fact *increase* entropy by introducing an infinity of colored configurations of people, plants, and pots in a room? Are they interesting because they "reduce information"? It seems I had to look at more than a hundred drawings (a data set) before I *found* information. Indeed, understanding Aaron's drawings was an inductive process, and the rules of operation I have surmised do "compress" the variety of the drawings. But there was no "information" in these drawings, I conceived something informative and conveyed my understanding in rulelike statements about how the drawings are generated.

But notice also how I worked: I didn't merely reason about the images as they were produced. I collected them over many days (having first invented a way of saving them), sorted them, and found ways of describing them (the ontology and rules of configuration). I worked with stuff in the world, not just "chunks of remembering." How I perceived the images changed as I conceived of ways of describing them. My imaginative work involved knowing how to use a computer system to organize thousands of images in folders, to import them into a photography program, and to produce a portfolio (106 drawings on twenty-eight pages with an introduction; Clancey 2005) that I could later study to remember my investigation. I made a product out of the study that I could share and reuse. My portfolio is itself an artistic composition with arrangements of Aaron's drawings, bound by the iPhoto computer tool in pages with one, two, three, four, or eight images (a limitation I also circumvented by including a screen capture with twelve drawings).

Regarding imagination as a "combination of remembered chunks," it is true that in analyzing Aaaron's drawings I used my knowledge of how such programs can be designed and the notions of grammars, constraints, and layered sequences of assembly (configure, layout, color). In creating the Aaron portfolio book, I used my knowledge of the photography program. I visualized a product analogous to what I had produced before using my own images, and that conception, a kind of template involving conceptual mapping, drove my project. But were these "memorized structures," or skills and ways of working? I adapted both design ideas and techniques. All that we know about neurological memory suggests that it is a memory of processes, of ways of behaving, not of stored things (descriptions, maps, and programs; Clancey 1997, chap. 3; Clancey 1999). And remembering is itself an experience, a behavior in time, often guided by representations and tools in the world.

But Ganascia does not mention the instruments or tools that facilitate induction because in his worldview creativity occurs in the timeless, placeless space of the "reasoner," in transformations of inputs and outputs formally codified. In the transactional worldview, a different kind of causal coupling arises between perception, conception, and manipulated physical materials, with simultaneous and sequential relations (Schön 1987; Clancey 1997, chap. 9). Ganascia's references to research into "scientific discoveries" have the same limitation, the vast majority couched only in terms of model manipulation, existing only in the space of the mental, and saying little if anything about exploration as it actually occurs (cf. Clancey 2001).

For Ganascia, the glimmer of another worldview arises when considering the work on conceptual mapping in machine learning—operations involved in “practical induction, as it was theorized in Aristotelian natural science”—and the work on reasoning by analogy. But when he refers to structural representation and matching, Ganascia is thinking in terms of logic expressions, that is, an articulated model constructed entirely of linguistic terms and relations. Such a model would, by conjecture, be the basis for young children’s drawing of imaginary pictures. Of course, given the language limitations of children, he states that this knowledge and reasoning must be unconscious—suggesting that the mind has created models that the child cannot create. So the plot thickens, or rather, we get deeper into a mire.

Again, I emphasize that Ganascia is writing about a struggle with the formalist point of view and not simply advocating it. Grounded at least a bit in real experience, he observes that “creative behavior consists . . . also in producing new ideas on which new conceptual spaces are built.” The reformulation of the problem in the “mutilated checkerboard” solution accepts the ontology of contiguous squares but adds a category of color. This is creative, but reconceptualization can be broader yet, involving different modes of thought, not restricted to named categories or even articulated meanings.

Notice how a mathematical formalism, a formal puzzle, becomes, without comment, an implicit standard for defining and formalizing the nature of creativity—indeed “problem solving” becomes a metric for characterizing what is creative. Where does this leave dance? Can the quantified mode of thought of logic be used to evaluate the quality (creativity) of the mode of thought of the arts and humanities?

Referring to interpreting large data sets as "reducing information" is already a puzzle chasing its own tail, for the work of understanding is to create (increase) information, to perceive patterns, and to conceive their meaning (e.g., understanding Aaron). Our everyday problem is to grasp complexity or apparent dissonance, to create information about the environment. In science this information might take the form of a generalized model that will allow better predictions—thus increasing information about the future (compare Ganascia: "it leads to removing information"). In human understanding, embracing conceptualizations assimilate, they order and organize experience, and they may do this in different ways across time and sensory-motor modalities (Clancey 1999).

The notion of "reduction" is based on quantification, whereas the cognitive process of comprehending is qualitative, relational, and constructive. In the representational flatland of logic, no distinction is made among the world of stuff, sensation, perceptual and conceptual categorization, feeling, and behavior. Combining a kitchen pantry of flour, fruit, sugar, and butter into a pie doesn't "reduce the ingredients," it creates a qualitatively new kind of entity, a baked good. The illusion that information is reduced by induction is rooted in the failure to distinguish the map and the territory. In the language of logic, baking is simply reducing the complexity of a wheat field to a pie. In the language of logic, creativity is like making a trip by moving on a map.

Ganascia notes the lack of relation between structural mapping and logical induction, which may reflect the attempt to model learning without modeling conceptualization. Explaining creativity in terms of logical induction alone entails viewing all knowing in terms of "knowing that" (Ryle 1949; Chemero 2002)—that is, of tangible and countable expressions. But human learning also involves practical control and know-how and doesn't necessarily require syllogisms and equations. Consider the role of information and reasoning in creating new skateboard gymnastics, a kind of modern dance.

Ganascia is telling us that it is difficult to equate human creativity with logical induction and machine learning, which is not too surprising given the volumes written about the logic of scientific discovery in the last fifty years. I think he is right to conclude that bringing together logic and creativity requires "conceptual space mapping," but the spaces he explores are not sufficient. Another, broader worldview is required, one that admits that different worldviews are possible, that there are indeed two kinds of people in the world. Perhaps switching partners would be helpful here.

Dance of the Systems: Crossing Disciplinary Boundaries

It is tempting to generalize from the three chapters to say something about types of "codes" of the intellect. This ground has been run over before, notoriously in talk about the digital (left brain) and the analog (right brain) (e.g., Hampden-Turner 1981, 86–89). Just as consciousness as a topic fell into disrepute within psychology for almost a century, the left-right talk has been viewed as unscientific. However, there is something important to preserve, which I've organized according to types of activities and types of conceptualizations (table 1).

Metaphors and viewpoints are mixed in this table, relating to reification of products and processes, affecting notions of time and causality. Wilden (1987, 231–42) suggests that the distinction here—which he summarizes as "logical" versus "ecological"—is not an opposition or contradiction but "two complementary forms of coding," which constitute two specialized capacities "constrained by the whole" (233). In other words, whether these are neurological processes (e.g., sequencing versus coupling), human activities (talking about versus doing something), or stages in theorization (refining ideas versus brainstorming), the different aspects depend on and influence each other.

Campbell suggests that the left-side categories correspond to information that is "coded in ways which are more strictly organized, more formal, stable, and free from error. They refer to modes of thought in which structure is of great importance, but structure of the kind in which one component is fitted to another, by a single connection, leaving no room for ambiguity or for multiple relationships" (1982, 243). Perhaps this is like the difference between English gardens and mountain meadows.

Table 2. Logical versus ecological modes of thought

Character of Activities	
Fixing	Nurturing
Resolution	Transaction
Deciding/Having an Idea	Doing/Embodying an idea
Determinism/Mechanization	Inquiry/Participation
Pinning down, Reification	Activity, Dance
Distinction	Assimilation
Knowledge as scientific	Knowledge as instrumental
Law-driven	Interpretive
Automate	Informate
The WORD	Dialog
Top-Down	Bottom-Up
Preserve	Construct
Idealization	Realization
Optimization	Dynamic
Apply	Relevate
Perfecting	Evolving
Control	Empower
What is the knowledge?	Who's knowledge?
Nemeses: Uncertainty, falsehood, disorder, unprincipled action, emotion, surprise	Nemeses: Bounds, power/authority, bean counting, impersonal, bureaucratic, pre-determined
Character of Conceptualization	
Objectify	Relate
One	Many
Knowing That	Knowing How
Things	Processes
Sequential	Simultaneous
Focal	Contextual
Statements	Melodies
Literal	Metaphorical
Excluding, extracting from context	Including, fitting into context

Perhaps paradoxically, the process of reifying and theorizing, which dominates the logicist perspective, becomes a deliberate tool for switching codes. But the apparent contradiction between the two perspectives lies in an objectivist worldview. Once multiple worldviews, indeed multiple formalisms and different logics, are admitted, the interplay between the perspectives becomes productive and dynamic (as realized in the work of Ceusters and Smith, as well as my assembling pages of a book from sorted drawings by Aaron). Conceptually, the blending of logical framework and ecology of materials may blend and alternate as perception, meaning, and action arise together (Clancey 1997, chap. 9; Schön 1987).

More broadly, the two perspectives represent different codes of conduct, a combination of values and methods for regulating a community's activities, including access to resources and privileges. Schooling is replete with examples of how to assess proficiency, with debates about the illusory primacy of propositional knowledge over skills. Disciplines evaluate performance according to their own epistemologies, with the arts and humanities emphasizing projects and portfolios and the sciences emphasizing faithful reproduction of accepted theories. Constraints of norms, genres, and settings tacitly and often, on reflection, explicitly regulate the creations of artists, writers, architects, instructional designers, lawmakers, medical providers, and so on (Schön 1979, 1987).

Wilden cautions that we need a "both/and" perspective throughout.[6] The two sides of table 1 are not opposing worldviews but modes of thought that build on each other. Extinguish one half and the activities and conceptualizations on the other half would cease to exist or would have a dramatically different character. As Dewey put one aspect of the relation: “The business of reason is not to extinguish the fires which keep the cauldron of vitality seething, nor yet to supply the ingredients which are in vital stir. Its task is to see that they boil to some purpose” (Dewey 1929, 587). I visualize these modes of thought as two icons: On the right, the many, diversity—a group of people with arms aloft and hands together in a circle (also, the multicolored rings of the Olympics); on the left, the one, purity—the glaring red eye of Hal in the movie *2001: A Space Odyssey*.

The challenge posed for these essays was framed originally as “fostering a dialogue . . . about the impact of digital information technology on thought and practice in the arts and humanities.” Yet my reading of the essays in this section suggests that we turn the topic around and consider *the impact of thought and practice in the arts and the humanities on digital technology.* An actor, for example, is well aware of the different mentalities of a performance and a script (Becker 1982, 61); switching codes is part of the actor’s everyday experience. But the technologist schooled in the logicist, technical rationality of the twentieth century is taught that scientific thinking is the only kind of truth (at worst, that theories are to be judged by their falsifiability rather than their directive value; Dewey 1938, 519). Learning that technical rationality is just one way of regulating human activity requires the logicist to recognize the dialectic between logic and ecologies of human activity, to appreciate an order, a form of intellectual life, that is not controlled, articulated, or expanded through reason alone, yet still benefits from and often relies on notations, models, and inference.

These essays illustrate how participating to become influential in another community requires scientists and engineers to fit their practices (including the tools they seek to foster) within the practices of that community (Greenbaum and Kyng 1991). Doing this with integrity requires, as Hendler relates so well, understanding that technical rationality is not in control, not a gold standard, and not the savior, but just one (sometimes very important) mode of thought and practice for bringing order to human affairs. So part of "what you do on Monday" is to join a group that lives on the other side and to see how you can be of service. From Hendler and Ganascia's perspective, this is the inverse of Ceusters and Smith's "dancing with the ontological engineers."

Table 1 tells us that there is no transcendent mode of thought but rather a dialectic between "objectifying" and "relating." But is there a transcendent point of view, an epistemology that includes all others? Perhaps, in a metaphysical sense, a transcendent idea is that there exist multiple points of view with validity in different (cultural) systems or for different purposes.

As psychologists who equated concepts with fixed symbols in the brain (Agre 1993; Clancey 1997) came into contact with social scientists, they sometimes felt that science itself was being undermined. Technical rationality, requiring coherent definitions, formal rules, consistency, completeness and a mathematical foundation for validity, is founded on the notion of models, and by assumption such models must correspond, have a truth relation, to the phenomenon of interest to be of value. Thus, from the perspective of TR, the notion of multiple worldviews has been regarded at times as cultural relativism that makes impossible a science based on absolute truth (Slezak 1989; Vera and Simon 1993). Yet scientists focusing on ecological problems, such as Lorenz, an ethologist (and even Bohr, a physicist), had long ago adopted a different view of change and complex systems, compatible with a constructivist (as opposed to objectivist) epistemology (Clancey 2008).

We must not, however, simply criticize TR and dismiss it. Rather, the point of table 1 is to provide a transcendent view that puts TR into perspective, making its contributions and indeed its necessity clearer. Thus, in some respect we might argue that it is fine and good for different schools of thought to operate in blissful isolation, as discrete academic societies, departments, and publications. For through this separation, as in the formation of species, different analytic frames, languages, and tools can mature. At some point, though, for some people inclined to "bridge the gaps," an intolerable discrepancy emerges, a tear in the fabric of our common heritage. Perhaps it will be a practical problem that forces a dialogue between communities (as global warming brings together scientists and politicians), or it might be a practical tool that sparks a creative "what if?" (as the Internet has been taken up by journalists, photographers, cooks, genealogists, and so on).[7]

The difference in mentality and practices then provides a potential to cross (cf. Ceusters and Smith), a field of play for intersecting and synthesizing modes of thought—exemplified by the objective of this volume. On the World Wide Web the potential to "relevate" across disciplines is so extensive, the blooming of a thousand flowers so unmistakable, we are thrown up into yet another plane, where we can now see the modes of thought, the speciation of disciplines. We observe from this higher plane, looking down on the river of language, thought, and culture, a continual dance of objectification and relevation, in the self, in society, and in the global community. The unifications have been occurring all along, particularly between the sciences and philosophy. The illusory triumphs of a field (such as the hubris of the AI researchers of the 1960s and 1970s) are but short-lived, mostly harmless eddies, in whose epistemological backwaters an idea can be explored to its limit, matured and admired, and then spit out into the main stream, where it can find its way into a larger activity, and in that flow be transformed into something more alive and uncertain in destination.

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NOTES

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[1]. In this commentary I use the term “code” informally, in reference to the theme of this book. In the discourse of artificial intelligence research, however, the term conjures up debates about representation and meaning. For this reason, because it suggests a certain “language of thought” that I reject, I would not ordinarily use the term to refer to worldviews (Altman and Rogoff 1987; Agre 1993, 62). By “code” here I mean broadly a “mode of thought,” involving and reflected in a conceptual system, attendant language or notation, and activities of some community of practice (e.g., the code of musical performance and theory; the code of the logicist-technologists who invented the semantic web).

[2]. Ironically, when Stanford researchers sought funding in the late 1970s to develop an expert system for pneumonia, to collect the best practices for a poorly understood disease, the National Institute of Health rejected the proposal on the grounds that the knowledge did not exist, so attempting to write rules for diagnosing pneumonia was premature.

[3]. Ryle (1949), Dewey (1938), and many others said this clearly, well before cognitivist psychology dominated the academic scene. For surveys see Clancey (1997) and Wallace et al. (2007).

[4]. The attitude seems related to the tag line of the 1960s US television show *Superman*: "Truth, justice, and the American way."

[5]. This version of Aaron has been available online since 2001 at http://www.kurzweilcyberart.com/aaron.

[6]. For extensive discussion of the nature of communication, particularly the issue of switching codes, see Wilden (1987). Wilden's title, *The Rules Are No Game*, reflects his interest in the relation between coded variety (the rules) and uncoded variety (the game), playing against Korzybski's dictum "The map is not the territory."

[7]. Although I focus here on technological change since the 1990s, the pattern is also evident in the broad sweep of history in the creation and bridging of political boundaries based on ethnicity, language, and religion.