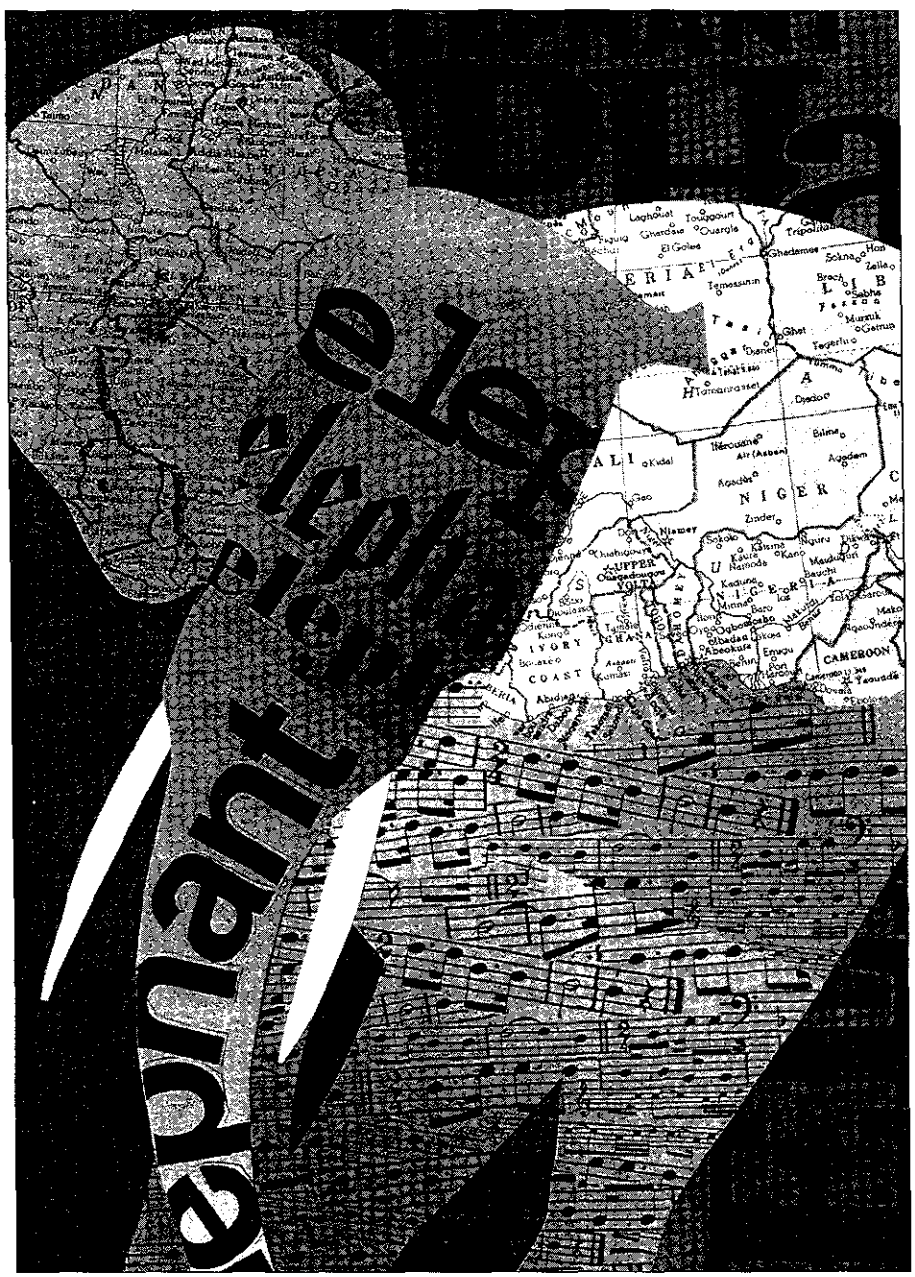
Of Mind and Media

How Culture's Symbolic Forms Affect Learning and Thinking

BY GAVRIEL SALOMON

Media's symbolic forms of representation are clearly not neutral or indifferent packages that have no effect on the represented information, Mr. Salomon points out. Being part and parcel of the information itself, they influence the meanings one arrives at, the mental capacities that are called for, and the ways one comes to view the world.



MIND AND media are allegedly two very different entities. One is taken to encompass the very essence of humanity — intelligence, emotion, compassion, will, and creativity; the other is often perceived as the cold, impersonal, dehumanizing, dull technology of the mass production of information for mass distribution. What could be more incompatible? And yet, history, research, and experience tell us that the two are intertwined in a number of ways. In this article I will briefly explore some of the re-

GAVRIEL SALOMON is dean of the School of Education, Haifa University, Haifa, Israel.

Illustration by Kris Hackleman

Concern with the symbolic aspects of information and their relation to learning peaked in the 1960s.

lationships between mind and media as they pertain to education.

Technology as Metaphor

One way in which mind and technological media interrelate is through metaphors. Throughout the ages, technology has been employed as a metaphor to explain human nature.[1] Thus we have the ancient Biblical metaphor of man as clay on the potter's wheel, and, in the Middle Ages, man as God's clockwork. In the late 19th century we have the human psyche captured by the metaphor of the steam engine, with its hidden, bubbling boilers and its hierarchy of controlling valves. In the early 20th century, film (unlike the theater) was considered to capture the irregular, associative nature of human thinking and remembering,[2] and a bit later human communication was represented as a telephone switchboard. In the 1980s, mental imagery was compared to pictures on a television screen, and nowadays the mind and its workings are likened to the computer — and the computer, to the human mind.

Employing technology and the communications media as metaphors for human existence and the mind, interesting as it is, may not have much educational significance. Does it really matter whether the computer is seen as truly thinking like a human or as only metaphorically "thinking,"[3] or whether the "pictures in our mind" resemble the pixels, frames, and other qualities of a TV screen? Ostensibly, metaphors are indeed only metaphors, and no educational or other implications should necessarily follow from them. However, the fact is that very important implications often follow from metaphors and other aids to perception. Consider, for example, the idea of the human mind as a computer (half-jokingly called "wetware"). It would follow from this conceptualization that the computer could serve as a genuine intellectual partner for its human peer. If that were the case, then the two could be seen as a single unit, and the development of the human intellect, in and of itself, would become unimportant. The *joint* human/computer system would be designed without any deliberate intentions for the cultivation of the human mind as a *separate* entity.[4] This would be very different from a design based on the premise that the computer is but a tool and the mind a separate entity to be developed for its own sake.[5]

Technology and mind also become interrelated in ways relevant to education through perceptions of learning and what it takes to promote it. When learning is metaphorically understood to be a matter of "absorbing" authority's teachings, then a chalkboard is just the right technology. When learning is understood as the reinforced connection of student responses to externally provided stimuli, then Skinner-box technology (or a worksheet) that offers small bits of fragmented information to which correct responses can easily be given and reinforced follows quite logically. Computer-assisted instruction (CAI), based as it is on the same kind of psychological understanding of learning, offers the same drill-and-practice pedagogy by means of a more advanced technology. Instructional television fits well with the old conception of learning as the relatively passive absorption of mainly concrete and attractively presented information. More recently, computer simulations, problem-guided explorations of the Internet, and other current, often team-based ways of employing computers have reflected a more active, self-guided conception of learning, a conception based on the metaphor of learning as a constructive process.

Symbolic Forms Of Representation

Technologies such as the chalkboard, Skinner boxes, instructional television, or CAI reflect certain perceptions of the modes of learning but not necessarily the symbolic forms in which the information-to-be-learned is presented. To a large extent, concern with the symbolic aspects of information and their relation to learning arose with the availability of film as an instructional medium. It reached its peak in the 1960s with the audiovisual movement and particularly with respect to instructional television.

Attention to the symbolic/representational nature of the information to be learned was influenced by the growing understanding of both human cognition and the psychology of symbol systems in art and communication.[6] It represents an important and interesting way of relating mind and media. For it is here that the media — construed in the sense of different technologically based uses of symbol systems — may exert the greatest and most direct influence on learning. It is here that one could ask, What difference does it really make whether a teacher uses, say, pictures instead of words, graphs instead of numbers, or video instead of still photos? Does it make a truly profound difference in learning if text is printed on paper or is glowing on a computer screen, or if the video is analogic or digital? If it does make a difference, in what sense does it make it? To whom? When? Under what conditions? How important is that difference? And especially, *why* does it make a difference?

It might sound strange, if not outdated, to raise such questions. Don't we know that a picture is worth a thousand words, that computers have an unsurpassed power to motivate, and that interactive multimedia embody the instructional promise of the near future? Yes, of course we know all that, but what is this knowledge based on? After all, daily impressions can be terribly misleading. Moreover, what do we do with competing knowledge, much of it emanating from research, showing that a single word might be worth a thousand pictures (indeed, how do you paint "nevertheless," "questionable," and "no"?); that differences in symbolic forms of representation, in and of themselves, do not always make much of a difference in learning; and that the real power of TV or computers may well be due to their contents, interactivity, and "busyness" rather than to their symbolic forms of representation?

A large body of research in which different media were pitted against one another, a tradition that occupied many educational researchers in the 1960s and the 1970s, yielded rather disappointing results. By and large the most frequent finding was that it did not really matter what form of symbolic representation one employed,

since all resulted in (allegedly) the same learning outcomes. But the same learning outcomes were found mainly because the researchers were seeking common achievements rather than ones that uniquely distinguished the different representational forms. In his introduction to one of the more illuminating books on the topic, David Olson observed, "Perhaps the function of the new media is not primarily that of providing more effective means for conveying the [same] kinds of information evolved in the last five hundred years of book or literate culture."[7]

Olson's comment echoes an earlier observation by Ludwig von Bertalanffy, one of the leading figures of general systems theory: "If the meaning of Goethe's *Faust*, of Van Gogh's landscapes, or Bach's *Art of the Fugue* could be transmitted in discursive terms, their authors should and would not have bothered to write poems, paint, or compose, but would rather have written scientific treatises."[8] In this light, it would have made much more sense for researchers to study what one can learn from, say, an exciting film about the brain's functions that does not duplicate what can be learned from an equally interesting oral lecture. Indeed, daily observations suggest that each form of representation is uniquely capable of selecting, packaging, transmitting, and conveying its own information in its own way, thereby affording a unique experience. Viewing Meryl Streep in the film *Out of Africa* is a rather different experience from reading the novel, which provides an entirely different experience from, say, listening to an African storyteller or actually wandering through Kenya's open spaces.

Different, even unique — perhaps, but why the differences? In what ways would these differences be experienced and with what learning consequences? To begin with, it is obvious that different forms of representation have what philosophers call different fields of reference. Musical notation is designed to represent the field of musical notes (which no drawing can), while language can best represent the field of logical relations (try to express the concept "because" using ballet movement), and mathematical notation represents mathematical relations (which film cannot). In other words, different symbolic forms of representation address different aspects of the world around us and thus afford us the opportunity to learn something different about the world from each form of representation.

Differences in Meaning

This much is, of course, pretty obvious. What is less obvious is that even when different symbolic forms of representation address the same field of reference, conveying (what appears to be) the same information — say, a verbal description of an event and a video rendering of it — the *meanings* one would derive from each might be pretty different: logical, somewhat abstract, and sequential in the former case; impressionistic, dense, and "fuzzy" in the latter. It would follow that reading a story might result in arriving at different meanings from those that would be derived from, say, watching a faithful video rendition of the story.

The less knowledge already available to the learner, the more the symbolic forms of representation will influence the meanings arrived at.

Is this necessarily the case? Is it always that way? Not according to some scholars, who claim that, ultimately, meanings are not a matter of "acquisition" from external sources; rather, the meanings we derive or construe during human communication are mainly a function of the mental ("constructivist") activity we engage in, strongly colored by the knowledge structures ("schemata") we already possess and bring to bear on the new information. Indeed, the meanings the readers of this article will arrive at will greatly depend on the parts of their existing knowledge structures into which they choose to assimilate the article's content. Thus it might follow that the symbolic forms of representation through which the content is conveyed would not affect the meanings ultimately derived as much as would the readers' existing schemata and immediate dispositions.

While this may be the case, it does not seem to be the only case. For much may depend on the richness and organization of the knowledge schemata one brings to bear on the incoming information. When the assimilatory schemata are rich with knowledge, well developed, and well organized, the meanings one construes from the incoming information will not depend much on the symbolic form in which that information is coded. If you are truly knowledgeable about the Civil War, then a new piece of information you encounter will be easily assimilated into your existing "Civil War Schema," and the meanings you will give the new information will be more or less the same, regardless of the mode in which the information was conveyed. However, if your relevant assimilatory schemata are still knowledge-lean, as when you only begin to acquire information in that domain, then the influence of the symbolic forms of representation may be far more profound. The meanings arrived at will greatly depend on whether the information is pictorial or verbal, numeric or graphic. In other words, the extent to which symbolic forms of representation affect meanings is a matter of balance between them and the richness of one's schemata: the less knowledge already available to the learner, the more the symbolic forms of representation will make a difference in the meanings the learner arrives at.

Different Mental Capacities

If different symbolic forms of representation address different aspects of the world, and if they code, package, elaborate, render, convey, and express them in particular ways, then would not "reading" them require different sets of mental processing capacities? Or are the differences in processing that we experience when we read a map, a page of a book, or a musical score just a matter of simple familiarity with the codes? If one has acquired knowledge of cartography, then is reading a map the same as "reading" a drawing of a landscape?

At least two lines of work suggest that

the "reading" of different symbolic forms of representation requires different sets of mental skills and capacities. One line emanates from neuropsychological research, and the other from media research. Each of these lines has its limitations, but the convergence of findings supports the conclusion that different symbolic forms of representation require different symbolic capacities. The larger the difference between the symbolic forms of representation, the greater the qualitative difference between the required capacities.

Neuropsychological work has quite consistently shown a division of labor between the two hemispheres of the brain. Whereas the left hemisphere is mainly concerned with processing language, the right hemisphere is more concerned with the processing of visual/spatial functions (but also with humor, metaphor, and nonliteral meanings). Finer divisions of labor exist as well: while damage to particular subareas of the frontal lobe may result in some difficulty in producing grammatical speech but not affect comprehension, damage to the temporal lobe results in difficulties in comprehension but not in fluency of speech.

One should not overstate the case, as if the two hemispheres operated in total isolation. In fact, they usually collaborate extensively, exchanging information and, during one's early years, even substituting for each other if needed. Nevertheless, one could generalize the case and suggest the hypothesis that basic symbolic forms of representation — language, number, spatial relations, movement, pitch — that are profoundly different from one another are most likely processed by different parts of the brain. Indeed, Howard Gardner cites support for this hypothesis, using it as one of the bases for his theory of multiple intelligences.[9] The seven intelligences he describes (linguistic, musical, logical/mathematical, spatial, bodily/kinesthetic, intrapersonal, and interpersonal) have, according to him, different neurological functions in the brain. These, in turn, provide the basis for differentiated symbolic capacities, each with its widening "spread" that allows it to handle symbolically based cultural products such as stories and caricatures, maps and sonnets. Particularly important, each such symbolic capacity has its own unique developmental progression, which depends, it seems, on both the structure of the symbol system under consideration (e.g., the grammatical requirements of language, the conservation of number in the number system), and the maturing of the relevant neuropsychological functions.

Research on media, particularly that part of it most concerned with the symbolic forms of representation, suggests a converging conclusion: different symbolic forms of representation are processed by different sets of mental skills and capacities. This appears to be the case within language, and it is the case within the representational forms employed by film and TV. In my own work, I have shown, for example, that a representational form such as abrupt cuts from close-ups to long shots calls upon the capacity of relating parts to wholes; children who have a better mastery of that particular capacity are also better capable of comprehending a television story that includes such a technique at crucial story junctions. On the other hand, the representational form of gradually zooming in and out appears to overtly "supplant" that capacity, thus rendering unnecessary the mastery of relating parts to wholes.

In another study five versions of the same film were produced, each emphasizing a different representational element: fragmentation of space (varying visual points of view), logical gaps (discontinuity of story line), long shots/close-ups, and the like. A battery of mental tests to measure mastery of the assumed relevant capacities was administered to children who then viewed one or another version of the film. Results clearly showed that, for each representational form, a different capacity was required to comprehend the plot, thus favoring children with the better mastery of the relevant capacity.[10]

If this is the case when different coding elements within the same symbolic forms of representation are employed, it would be expected to be at least equally true when different symbolic forms of representation are employed. Indeed, this is what has been found in other studies in which televised versions of a story were compared with as-equivalent-as-possible print versions. Findings were consistent. Aside from a common core of capacities (such as comprehension of story grammar), each symbolic form of representation required another set of skills for its intelligent handling: linguistic capacities for the better comprehension of the print version, TV-related skills for the TV version.

Different Perceptions of the Media

Different media, because of their differential capitalization on different symbolic forms of representation, exert differential influence on learning not only because of what they are, but also because of what they are *perceived* to be. The two may be quite independent of each other, although it would make more sense to assume that the way the media are and the way they are perceived to be are reciprocally affecting each other. Is TV indeed "shallow"? Is print indeed a medium that taxes the intellect? As Elihu Katz and his colleagues wrote,

> When people associate book-reading, for example, with a desire to know oneself, and newspapers, with the need to feel connected to the larger society, it is difficult to disentangle perceptions of the media from their intrinsic qualities. Is there anything about the book as a medium that breeds intimacy? Is there something about newspapers that explains their centrality in socio-political integration? Or is this "something" simply an accepted image of the medium and its characteristic content?[11]

Significantly, I and others have found that children often tend to handle a medium more on the basis of the general image they hold of it than on the basis of its particular offering or intrinsic attributes. Symbolic forms of representation that are perceived to duplicate reality closely (e.g., pictures) are taken to require no knowledge of authorship and no skill for processing.[12] Television, as a general rule, is perceived to be fun, simple, easy to understand, and generally useless. Comprehending televised content is perceived to require no brains, while failing to comprehend it is a sign of stupidity. On the other hand, print is generally perceived to be highly demanding, and success in comprehending a story in print is regarded as a matter of ability. Failing to comprehend print is expected because it is "tough."

Do these differential perceptions make a difference in learning? Indeed, they do! In line with such perceptions, children do not expend much mental effort on a televised story, even when it is quite poetic and requires effort. Thus they learn far less from it than from an equivalent story in print. The largest and most impressive difference in responses is found in the more intelligent children, who mobilize their ca-

Studies suggest that different symbolic forms of representation are processed by different sets of mental skills and capacities.

pacities to learn from the print story but forgo doing so when it comes to TV.[13]

Are these differences due to the intrinsic nature of TV and of print? Not really. When children are told to watch a television program not for fun but to learn something from it, their expenditure of mental effort rises dramatically, and with it, the quality of learning outcomes.[14] Quite clearly, children's differential perceptions of the media and of symbolic forms of representation ("pictures are realistic and hence require less mental effort than print") reflect the views of the social world around them. Where or when television is perceived as a serious medium (as was the case in Israel in the early days of television), processing capacities become mobilized, and much learning takes place. Not so when the medium is taken to be "just pictures." The socially held and communicated views of the media appear to affect the way children handle them, the depth with which they process their offerings, and thus what they actually learn from them.

Forms of Representation As Tools of the Mind

Last, and perhaps most important, we need to ask whether the different symbolic forms of representation not only offer different meanings, require different mental capacities, and are differentially perceived, but also whether they leave some differential cognitive residue. That is, do they somehow affect the way we come to perceive or represent the world to ourselves? Do they affect our cognitive apparatus in some lasting way, thus coming to serve as tools of the mind?

There is an assumption underlying these questions. The assumption is that there is some kind of isomorphism between the symbolic forms of representation employed by a culture's communications media and the arts, on the one hand, and by our cognitive/representational systems, on the other. It is as if we "come to think in terms of," say, 3-D perspectives, a representational form we have acquired from geometry and the arts, or in terms of slow motion, acquired from the language of film. Gardner's theory of multiple intelligences, mentioned earlier, alludes to this possibility in the sense that we may initially possess the neurological groundwork for the handling of a number of basic symbol systems such as language, number, and picture. Further developments of these capacities are related to interactions with the media and the different forms of art, reciprocally enriching our ways of seeing the world.

The Whorfian hypothesis, according to which the language we have mastered influences the way we perceive our world, comes readily to mind: "We dissect nature along lines laid down by our native language. . . . The world is presented in a kaleidoscopic flux of impressions which has to be organized by our minds — and this means largely by the linguistic systems of our minds."[15] Findings from research that was designed to test the Whorfian hypothesis have been pretty inconclusive.[16] The fact that one's language does not include a word to describe a particular texture of ice does not mean that, when needed, a relevant term will not be made up. Similarly, the fact that a culture has no particular word for "yesterday" to distinguish it from "the day before yesterday" does not mean that the people fail to think in terms of that distinction. And, as other research has shown, hands-on experience affects the grouping of objects as much as does the syntactic structure of one's language.

Quite clearly, people learn to make necessary perceptual distinctions and then to capture those experiential distinctions linguistically. In other words, it stands to reason that experience and language develop in reciprocally reinforcing ways, determining each other. One sees what one's language points out, and one comes to develop linguistic forms that capture what one experiences. But what if one is exposed to some novel symbolic forms developed in the arts or the media, forms that are not paralleled by any firsthand experience? What, for example, about the possible employment of such forms as filmic slow motion or cartographic contour lines as tools of the mind? Would much exposure to slow motion or actual cartographic mapping make one come to think in terms of these forms?

My own research, carried out in the 1970s and early 1980s, tends to support such a possibility.[17] Children exposed to novel symbolic forms of representation typical of film and television (e.g., zooming in and out, long shots and close-ups, animated breakup of space) have shown evidence of coming to use these forms in their thinking. As one student commented, "I have learned to think of my life as a series of frames partly overlapping each other and dissolving into each other." My findings came from both controlled experiments and natural field and cross-cultural studies. The latter, being of greater ecological validity, are of particular relevance here. I found that children's prolonged exposure to TV, provided that they expend effort in processing its messages, results in measurable changes in their mastery of relevant capacities.

Such cognitive effects are pretty important to note, as they may imply both desirable and undesirable consequences. On the one hand, involvement in artistic activity, expressing oneself through culturally afforded artistic symbolic forms of representation, is very likely to enrich one's cognitive/representational arsenal.[18] Mindful (unlike mindless!) exposure to art and to the media may have similar effects. However, there is a flip side to all of this. Exposure to the "busy" forms of today's television, particularly MTV and its like, may cultivate a preference for a quick-paced, erratic, even chaotic way of handling information. Indeed, in one of my earlier studies I found that heavy exposure of Israeli children to the then-novel, jazzed-up formats of "Sesame Street" resulted in observable decreases in their perseverance. This does not mean that they became incapable of persevering with a continuous, school-like task but that they came to prefer to "jump around" impatiently, emulat-

ing in their thinking the program's formats.

Current technological media, particularly the Internet and many of the interactive multimedia packages available today, may affect their users' minds in a similar way. As interactivity replaces sheer exposure, such effects may become even stronger. The isomorphism between media's symbolic forms of representation and those of our cognitive apparatus may be most strongly manifested here, as both human comprehension and these media are based on the creation of and "movement" within networks of connected knowledge. This assertion deserves some elaboration.

One way to describe comprehension is as a network of relations among "nodes" of knowledge. It can be argued that a single bit of information cannot be comprehended except as part of a network of relations with other such nodes. For example, the difficulty of trying to memorize historical dates is that they often remain unconnected, free-floating in one's cognitive space, and thus quite incomprehensible and meaningless. It is only when the study of history is turned into a narrative-like web of connected themes (a story) that the single event or date becomes meaningful. The denser the web of connections, the richer the meaningfulness of the single item. Coming to comprehend something means networking — creating a network or web.[19]

But the connections of which such a web consists can be of various kinds. The study of a discipline requires certain logical relations that are favored by that discipline: causal, correlational, part/whole, rule and exception, principle and derivatives, temporal, spatial, and so on. But a web can also consist of other, far less scientific relations, particularly free, idiosyncratic, and thus often unexplainable associations. Although one can cognitively "move" from one idea to another with great ease, there may be no logical connection between the elements. This free associating may be a desirable way of brainstorming, occasionally leading to the generation of creative ideas. But this is not the way that school-based acquisition of disciplined fields of knowledge is supposed to go.

The Internet and other computer products and possibilities (particularly multimedia programs) are similarly based on the idea of a web, this one connecting sites, information packages, and participants. All these technologies afford quick and efficient connectivity and easy access to the different "nodes." This, of course, is their strength, allowing self-guided exploration and targeted information searches, in the best of the constructivist spirit. They also seem to be gradually changing the meaning of "knowledge," from something that is possessed to something to which we have access.[20]

But this could as easily be their weakness, even their cognitive downside. For what these developments allow is an undisciplined, free-associational, yet tempting wandering among the various nodes ("web surfing"). Students have been observed to start exploring the life cycles of elephants in Central Africa but to very quickly find themselves following a lead that takes them to the biography of Napoleon or to the political situation in Turkey. Nothing constrains free-floating surfing on the basis of associations and the lure of interesting yet logically unrelated leads.

As suggested above, the isomorphism between mind and media here reaches one of its high points: networking as a cognitive function as well as a technologically based form of information structuring that affords easy access and navigation. Would not interaction with such a technology strengthen the preference for mental networking as free association at the expense of a more demanding, disciplined web? This possibility has yet to be explored or its potential consequences — both positive and negative — for education seriously considered.

Mind and technological media are not two unrelated entities. They affect each other in a variety of ways. Technological media are, of course, the creation of the human mind, but they in turn affect their creator. Media's symbolic forms of representation are clearly not neutral or indifferent packages that have no effect on the represented information. Being part and parcel of the information itself, they influence the meanings one arrives at, the mental capacities that are called for, and the ways one comes to view the world. Perhaps most important, the culture that creates the media and develops their symbolic forms of representation also opens the door for those forms to act on the minds of the young in both more and less desirable ways.

---

1. D. J. Bolter, *Turing's Man: Western Culture in the Computer Age* (Chapel Hill: University of North Carolina Press, 1984).
2. Hugo Munsterberg, *The Film: A Psychological Study* (1916: reprint, New York: Dover Publications, 1970).
3. See, for example, John R. Searle, *Minds, Brains, and Science* (Cambridge, Mass.: Harvard University Press, 1984).
4. Roy D. Pea, "Practices of Distributed Intelligence and Designs for Education," in Gavriel Salomon, ed., *Distributed Cognitions* (New York: Cambridge University Press, 1993), pp. 47-87.
5. Marlene Scardamalia et al., "Computer-Supported Intentional Learning Environments," *Journal of Educational Computing Research*, vol. 5, 1989, pp. 51-68.
6. See, for example, Ernst H. Gombrich, *Art and Illusion* (New York: Bollinger Foundation, 1960); and Nelson Goodman, *The Languages of Art* (Indianapolis: Hackett, 1968).
7. David R. Olson, Introduction to David R. Olson, ed., *Media and Symbols: The Forms of Expression, Communication, and Education: 73rd NSSE Yearbook, Part I* (Chicago: National Society for the Study of Education, University of Chicago Press, 1974), p. 8.
8. Ludwig von Bertalanffy, "On the Definition of the Symbol," in Joseph R. Royce, ed., *Psychology and the Symbol* (New York: Random House, 1965), p. 41.
9. Howard Gardner, *Frames of Mind: The Theory of Multiple Intelligences* (New York: Basic Books, 1983).
10. Gavriel Salomon, *Interaction of Media, Cognition, and Learning* (San Francisco: Jossey-Bass, 1979; Hillsdale, N.J.: Lawrence Erlbaum, 1994).
11. Elihu Katz, Jay G. Blumler, and Michael Gurevitch, "Utilization of Mass Communication by the Individual," in Jay G. Blumler and Elihu Katz, eds., *The Uses of Mass Communications* (Beverly Hills, Calif.: Sage, 1974), p. 26.
12. Gavriel Salomon, "Television Is 'Easy' and Print is 'Tough': The Differential Investment of Mental Effort in Learning as a Function of Perceptions and Attributions," *Journal of Educational Psychology*, vol. 76, 1984, pp. 647-58.
13. Gavriel Salomon and Tamar Leigh, "Predispositions Debilitate Learning from Television," *Journal of Communication*, vol. 34, 1984, pp. 119-35.
14. Salomon, "Television Is 'Easy.'"
15. Benjamin Whorf, *Language, Thought, and Reality* (Cambridge, Mass.: MIT Press, 1956), p. 212.
16. See, for example, Michael Cole and Sylvia Scribner, *Culture and Thought* (New York: Wiley, 1974).
17. Salomon, *Interaction of Media, Cognition, and Learning.*
18. Thomas Hatch and Howard Gardner, "Finding Cognition in the Classroom: An Expanded View of Human Intelligence," in Salomon, *Distributed Cognitions.*
19. Gavriel Salomon and David Perkins, "Learning in Wonderland: What Do Computers Really Offer in Education?," in Steven Kerr, ed., *NSSE Yearbook* (Chicago: National Society for the Study of Education, University of Chicago Press, forthcoming).
20. Herbert A. Simon, *The Sciences of the Artificial* (Cambridge, Mass.: MIT Press, 1982).